

Wyoming Landscape Conservation Initiative Science Workshop

May 14 - 17, 2012




Changing Landscapes: Development and Influence of Energy and Mineral Resources



Understanding the Influence of Land Use and Energy Development on
Wildlife Populations and Their Habitats



Assessing Landscapes and Monitoring Change



Addressing Change through Management and Conservation Actions



WLCI Executive Committee

Mary Thoman	WLCI Chair, Sweetwater County Conservation District
Cheryl Chatham	U.S. Forest Service
Jason Fearneyhough	Wyoming Department of Agriculture
Steve Ferrell	Governor Liaison Resource Advisor
John Keck	National Park Service
John Linn	Sublette County Commissioner
Mark Sattelberg	U.S. Fish and Wildlife Service
Don Simpson	Bureau of Land Management
Scott Talbott	Wyoming Game and Fish Department
Randy Updike	U.S. Geological Survey

WLCI Coordination Team

Michele Windsor	BLM - Lead	307-352-0227	mwindsor@blm.gov
Pat Anderson	USGS	970-226-9488	andersonpj@usgs.gov
Justin Caudill	WDA	307-350-5480	Justin.caudill@wyo.gov
Amy Nicholas	FWS	307-352-0140	amy.nicholas@fws.gov
Jim Wasseen	WGFD	307-352-0313	jim.wasseen@wyo.gov
Carolyn Liedtke	Team Assistant	307-352-0397	cliedtke@blm.gov

This document was printed through a grant from the Sweetwater County Travel and Tourism Board and the Sweetwater County Conservation District.



Cover Design by Suzanna Carrithers Soileau

Conference Organizers

Conference Committee

Pat Anderson USGS Fort Collins Science Center	Dan Blake USFWS Klamath Falls FWO	Zack Bowen USGS Fort Collins Science Center
Frank D'Erchia USGS Rocky Mountain Area Regional Office	Adrienne Pilmanis BLM Wyoming State Office	

Lead Session Planners

Laura Biewick – Session I USGS Central Energy Resources Science Center	Jeffrey Kershner Co-lead Session II Northern Rocky Mountain Science Center	Steve Germaine Co-lead Session II USGS Fort Collins Science Center
Steve Garman – Session III USGS Rocky Mountain Geographic Science Center	Pat Anderson – Session IV USGS Fort Collins Science Center	

Additional Session Planners

Chris Aimone Uinta County Weed & Pest	Tim Assal USGS Fort Collins Science Center	Erik Beever Northern Rocky Mountain Science Center	Zack Bowen USGS Fort Collins Science Center
Geneva Chong USGS Northern Rocky Mountain Science Center	Bob Lanka Wyoming Game and Fish Dept, State Office	Carolyn Liedtke BLM High Desert District	Dan Manier USGS Fort Collins Science Center
Robert McDougal USGS Crustal Geophysics & Geochemistry Science Center	Bob Means BLM Wyoming State Office	Amy Nicholas USFWS Ecological Services Wyoming Field Office	Jess Montag USGS Fort Collins Science Center
Ed Olexa Northern Rocky Mountain Science Center	Tom Owens USGS Rock Mountain Area Regional Office	Adrienne Pilmanis BLM Wyoming State Office	Amy Pocewicz The Nature Conservancy, Lander, WY
Chris Potter USGS Central Energy Resources Science Center	Cathy Purves Trout Unlimited Lander Office	Pati Smith Encana Oil & Gas (USA) Inc	Mike Sweat USGS Wyoming Water Science Center

Randy Teeuwen Encana Oil & Gas (USA) Inc.	Anna Wilson USGS Central Mineral and Environmental Resources Science Center
---	--

Tour Planners

Trisha Cartmell BLM Rock Springs Field Office	Kathy Fine BLM Rock Springs Field Office	Carolyn Liedtke WLCI CT, BLM High Desert District	Randy Teeuwen Encana Oil & Gas (USA) Inc.
Michele Windsor WLCI CT, BLM High Desert District			

Acknowledgements

The Conference Committee would like to thank all the session and tour planners. In addition we would like to thank Natalie Latysh and Gail Montgomery for web applications, Renee Dana, Serena Baker and the WLCI Communication Team, Bonnie Cannon, Pati Smith, Mary Thoman, Carolyn Liedtke, Suzanna Carrithers Soileau, Terri Hicks, and numerous others involved with outreach and reviewing workshop related documents, the leadership of the WLCI Executive Committee and WLCI Coordination team members, and of course all the presenters for which there would not be a workshop without them.

Contents

Speaker Abstracts	6
Session I. Changing Landscapes: Development and Influence of Energy and Mineral Resources	6
Oral Presentations.....	6
Posters Presentations	10
Session II. Understanding the Influence of Land Use and Energy Development on Wildlife Populations and Their Habitats	13
Oral Presentations.....	13
<i>Session II A. Energy Development, Life History, and Movements of Large Ungulates.....</i>	13
<i>Session II B. Energy Development, Life History, and Habitats of Birds, Fish, and Small Mammals.</i>	16
<i>Session II C. Greater Sage-Grouse and Human Development.....</i>	19
<i>Session II D. Inventory and Modeling Tools and Conservation of Greater Sage-Grouse in SW Wyoming</i>	23
Poster Presentations	25

Session III. Assessing Landscapes and Monitoring Change (tools, approaches, and methodologies)	27
Oral Presentations.....	27
<i>Session III A. Concurrent Topic: Muddy Creek, Carbon County</i>	27
<i>Session III B. Concurrent Topic: Assessment and Decision-Aid Tools</i>	31
<i>Session III C. Ecological Assessments & WLCI Focal Ecosystems</i>	34
<i>Session III D. Monitoring Methods, Approaches, and Tools</i>	38
Poster Presentations	41
Session IV: Addressing Change through Management and Conservation Actions	45
Oral Presentations.....	45
<i>Session IV A. Distribution, Evaluation and Treatment of Invasive Plants</i>	45
<i>Session IV B. Concurrent Topic: Conservation Planning, Partnerships, and Ecosystem Services</i> ..	48
<i>Session IV C. Concurrent Topic: Evaluation of Habitat Treatments, Management Considerations, and Science Needs</i>	51
<i>Session IV D. Reclamation and Restoration of Disturbed Lands and Important Aquatic and Terrestrial Habitats</i>	53
Poster Presentation.....	57

Speaker Abstracts

In order of presentation with presenting author in bold

Session I. Changing Landscapes: Development and Influence of Energy and Mineral Resources

This session focuses on energy and mineral resource topics that require improved scientific understanding in order to manage and conserve Wyoming's natural resources. Research and operations activities by Federal, State and local governments, academia, the private sector and others, together provide a landscape-level understanding of emerging issues, and contribute to responsible resource development and management decisions.

Oral Presentations

Energy Map of Southwestern Wyoming: Energy Data Archived, Organized, and Accessible

Laura R.H. Biewick, USGS Central Energy Resources Science Center, Denver, CO, Nicholas R. Jones, University of Wyoming Enhanced Oil Recovery Institute, Laramie, WY and Anna B. Wilson, USGS Central Mineral and Environmental Resources Science Center, Denver, CO

To help drive sound energy resource decisions, geologic information needs to be adequately archived, organized, and published in a manner that provides easily accessible information via Geographic Information Systems (GIS) and other research-related software for use by a variety of disciplines. The U.S. Geological Survey (USGS) has a long standing program assessing energy resources, including coal, gas, oil, uranium, and geothermal, as well as assessing environmental and health effects of the development and utilization of these resources. The accumulated data representing decades of research by the USGS are complimented by the results of similar activities by the Wyoming State Geological Survey, the U.S. Bureau of Land Management, industry and others, and all have been assembled into one geodatabase. The Energy Map of Southwestern Wyoming, prepared in two parts, is designed to facilitate a landscape-level approach to multidisciplinary science assessments, and science-based resource management decision-making. Part A contains data associated with the electrical power sources of coal and wind, and is here presented orally and as a poster session. The discussion includes (1) coal fields in this and surrounding areas, (2) the Laramide Orogeny and the paleogeography that determined the sites of coal accumulation during the Late Cretaceous and early Tertiary time, (3) energy resource assessments, and (4) wind resources and wind farms. Part B is in progress and will include oil, gas, uranium and solar resource information, as well as related features including infrastructure associated with exploration, production and development, and the extent and nature of restrictions or impediments to energy resources development.

Laura R.H. Biewick, USGS Central Energy Resources Science Center, P.O. Box 25046, MS 939, Denver Federal Center, Denver, CO 80225-0046, Email: lbiewick@usgs.gov.

Energy Mineral Development in Southwest Wyoming - an overview

Nicholas R. Jones, University of Wyoming Enhanced Oil Recovery Institute, Laramie, WY

Discovery of Wyoming's mineral riches dates back several hundred years to when early explorers and trappers learned of the numerous outcrops of coal and oil springs from North American Indian Nations. In the late 1800's word of these mineral occurrences spread and Wyoming became the locus and boom of mineral development. Following the Civil War the United States endeavored itself to connect the east coast with the west coast and construction of the transcontinental railroad began. As the grades were leveled and tracks laid, Rail-End towns were established and the first commercial coal mines began production in 1862. The development of these mineral riches set the ground work, shaped the infrastructure, and brought with it a rich diversity that Wyoming communities experience today. Currently Wyoming coal production accounts for roughly 40 percent of total US production of which nearly 12 million tons of coal is produced in Southwest Wyoming alone. In 2010 state revenue generated from Ad Valorem, Lease sales, Royalties, and Severance taxes on coal reached one billion dollars.

Nicholas R. Jones, University of Wyoming Enhanced Oil Recovery Institute, 1000 E. University Ave. Laramie, WY 82071, Email: njones@uwyo.edu.

Natural Gas Wells and Related Development on Surface Resources in the Pinedale Anticline and Jonah Gas Fields, Sublette County, Wyoming

Timothy J. Zebulske, BLM Pinedale Field Office, Pinedale, WY

The history of Sublette County, Wyoming, includes 100 years of oil and natural gas development. In the Pinedale Anticline and Jonah gas fields in the past 15 years, about 4,000 wells have been drilled and about 12,000 acres of surface disturbed for access roads, well pads, pipelines, compressor stations and liquids processing/disposal facilities. Oil/gas lease operators, in cooperation with the Pinedale Bureau of Land Management (BLM) and other agencies, have tried a variety of practices intended to reduce resource effects and expedite reclamation of disturbed areas. In 2002, surface disturbance averaged about 5-6 acres per well and each well required 7 to 8 weeks from start to finish, but by 2011, surface disturbance was reduced to less than 2 acres per well and drilling times decreased to about 15 days. This presentation highlights some of the past and present development and management practices used in the Pinedale Anticline and Jonah gas fields, and illustrates their effects on resources.

Timothy J. Zebulske, BLM Pinedale Field Office, 1625 West Pine St., P.O. Box 768, Pinedale, WY 82941-0768, Email: tzebulsk@blm.gov.

Overview of Encana's Jonah Field and Proposed NPL Project

Paul Ulrich and Randy Teeuwen, Encana Oil & Gas (USA) Inc., Pinedale, WY

Encana will discuss the current projects, purposes, benefits and challenges of natural gas development in Southwest Wyoming. Topics will include the basics of directional and

vertical drilling, well completion, project plans for the Normally Pressured Lance (NPL), employment and economic contributions to Wyoming. The Jonah Field will also be reviewed and include the formation and history of the field, amount of gas produced and current production. Encana will discuss the current EIS of the NPL project and the associated resource challenges, including air quality, wildlife (including sage grouse), water, grazing and socio-economic benefits. The presentation will include new technology and best management practices deployed in NPL, such as the three-phase gathering system, regional gathering facilities and electrification of the field. Encana will also share results of an Operator Committed Practices (OCP) group that independently developed a list of concerns and recommendations which have been shared with the BLM, Encana and the public. Encana's effort to work closely with stakeholders and its response to the recommendations will be discussed.

Paul Ulrich, Encana Oil & Gas (USA) Inc., 370 17th Street, Suite 1700, Denver, CO 80202, Email: paul.ulrich@encana.com

Mineral Resources of the Wyoming Landscape Conservation Initiative (WLCI) Study Area - Past, Present, and Future

Anna B. Wilson, USGS Central Mineral and Environmental Resources Science Center, Denver, CO

Historically, mining has been a major and diverse industry in southwest Wyoming, but in recent years only a few mineral resources (other than coal) are actively being sought or exploited. Within the Wyoming Landscape Conservation Initiative (WLCI), there are 16 districts, covering less than 20% of the total study area, where interest in mineral resources is, or has been, concentrated. Current significant mining activity in the WLCI is focused in only 3 of the 16 regions for trona (soda ash) and uranium. Near-future activity, although uncertain, is likely to be sought on a large-scale for only trona and uranium. Other industrial minerals, such as sand and gravel, stone, gypsum, and barite, etc. are not included in this study. The world's largest trona deposit (covering almost 3,600 km²), located in the southwestern part of WLCI, remains an economically viable commodity in today's market. Uranium exploration was intense from the late 1950s into the 1970s, with activity in Ketchum Buttes, Poison Basin, Crooks Gap-Green Mountain, Shirley Basin, and Great Divide Basin. Today, the major mines in Crooks Gap-Green Mountain are either reclaimed or idle, Shirley Basin has been almost entirely reclaimed, and Ketchum Buttes appears abandoned, but there are proposed in-situ recovery projects being pursued in Great Divide Basin and Poison Basin. Most of the base- and precious-metals (including gold, silver, copper, lead, and zinc resources) in the Lake Alice, Encampment, Seminoe, Iron Formation NE, Big Creek, Cooper Hill, Gold Hill, Herman, and Keystone districts were first explored and developed in the late 1800s and abandoned by the early 1900s. Some of them were re-explored or reactivated in the World War II era. Only a few were active in the 1970s to 1980s and nearly all have been abandoned. All the phosphate mines (for example, Leefe and South Mountain) and prospects in the western part of the study area appear to have been either abandoned or reclaimed.

Anna B. Wilson, USGS Central Mineral and Environmental Resources Science Center, P.O. Box 25046, MS 973, Denver Federal Center, Denver, CO 80225-0046, Email: awilson@usgs.gov.

A Probabilistic Approach to Estimates of Future Oil and Gas Development Impacts

Sarah J. Hawkins, Troy A. Cook, Seth S. Haines, USGS Central Energy Resources Science Center, Denver, CO and James E. Diffendorfer, USGS Rocky Mountain Geographic Science Center, Denver, CO

Increasing demand for a domestic energy supply has led to an increase in development impacts in areas rich in these resources. Development of continuous oil and gas accumulations (coalbed gas, tight gas, shale gas, shale oil) requires regularly spaced wells accompanying infrastructure over broad areas. The cumulative surface disturbance of such development has an impact on water and biological resources, but the severity and specifics of the impacts often vary with the landscape and oil and gas development style. To quantify the impacts of developing a given area in a manner that includes estimates of uncertainty, a probabilistic multidisciplinary approach is needed. Probabilistic modeling provides an approach for linking multidisciplinary aspects with energy and mineral assessments, and builds on an extensive existing dataset. The U.S. Geological Survey (USGS) National Assessment of Oil and Gas Resources Project produces assessments of the technically recoverable undiscovered oil and gas resources in priority sedimentary basins of the United States. The reports provide the necessary information to probabilistically model the potential energy development of an oil and/or gas accumulation. We propose to use this information, along with impact-related biologic and hydrologic data and documentation, in a Monte Carlo framework to estimate the potential impacts of future oil and gas development, and conversely, the impacts of restrictions on surface disturbance. While the approach will not generate spatially explicit maps detailing exact locations of roads and pads, it will output a set of probabilistic estimates of the impacts to a given area, as well as related spatial information.

Sarah J. Hawkins, USGS Central Energy Resources Science Center, P.O. Box 25046, MS 939, Denver Federal Center, Denver, CO 80225-0046, Email: shawkins@usgs.gov.

Rancher Perceptions of Energy Development in Southwest Wyoming

Jessica M. Montag, USGS Fort Collins Science Center, Fort Collins, CO, and Katie M. Lyon, Colorado State University, Fort Collins, CO

The rural lifestyle and socioeconomics of the Green River Basin in southwest Wyoming is being challenged by expanding energy development of all types. This includes approximately 83 trillion cubic feet of technically recoverable natural gas which amounts to almost one-tenth of US natural gas production; a quarter of the world's proven oil reserves, mostly in oil shale deposits; large reserves of uranium; and the world's largest reserve of trona. Since the latest energy "boom" in the 2000s, there has been a lack of research on energy development effects on the ranching community. Through an agreement between the Wyoming Department of Agriculture and the U.S. Geological Survey, a study evaluating ranchers' perceptions towards energy development was conducted. Surveys were mailed to 860 ranchers operating in Lincoln, Sublette, Uinta, Sweetwater, and Carbon Counties; 205 completed surveys were returned for an overall response rate of 24%. The mail questionnaire focused on the following themes: effects of energy development on quality of life factors; concerns about existing or potential effects to rangelands; challenges to ranching and the ranching industry; direct effects of energy development on ranching operations; perceptions towards land management agencies and

decision making processes; and the use of science in policy making processes. Results indicate that energy development is having a negative effect on drugs, crime rates, scenery/views, open space, traffic congestion, affordable housing, and availability of ranching supplies. Energy development is having a positive effect, however, on employment opportunities, salary amount, community economic development, and small business development. The results reflect previous research done in the 1970s in terms of respondents' perceptions in regards to positive and negative effects of energy development to their community. Research and management implications will be discussed.

Jessica M. Montag, USGS Fort Collins Science Center, 2150 Centre Ave., Bldg. C, Fort Collins, CO 80526-8118, Email: montagi@usgs.gov.

Posters Presentations

A Tale of Two Land Uses in the American West: Rural Residential Growth and Energy Development

Timothy J. Assal and Jessica M. Montag, USGS Fort Collins Science Center, Fort Collins, CO

This paper describes a spatiotemporal land use map for Sublette County, Wyoming. The county has undergone recent land use change in the form of heightened rural residential development on private land and increased energy development on both public and private land. The population of Sublette County nearly doubled over the last 25 years and is expected to grow by 50 percent by 2030. We are interested in understanding recent patterns of rural residential development (i.e. areas outside of town boundaries); a phenomenon that is rarely analyzed in a spatially explicit manner. The primary mechanism of land use change on portions of public land in the county is due to energy development. The Jonah and Pinedale Anticline Natural Gas Fields have each had an exponential increase in the number of wells drilled since the late-1990s. Additional wells require infrastructure such as well pads, roads and pipelines that creates a disturbance on the landscape. We sought to understand the relationship between the number of wells at each field and the size of the disturbance. In this study we integrate energy production data, population census data, ownership parcel data, and landscape metrics derived from a series of Landsat Thematic Mapper and Enhanced Thematic Mapper scenes (over a 25 year period) to create a map that illustrates the changing landscape. Sublette County has a wealth of wildlife and associated habitat which is affected by both types of growth. While we do not attempt to quantify the effect of disturbance on wildlife species, we believe our results provide important baseline data that can be incorporated into land use planning and ecological-wildlife research at the landscape scale.

Timothy J. Assal, USGS Fort Collins Science Center, 2150 Centre Ave., Bldg. C, Fort Collins, CO 80526-8118, Email: assalt@usgs.gov.

Western Energy Citation Clearinghouse (WECC)

Jessica M. Montag, Carolyn J. Willis, and Levi W. Glavin, USGS Fort Collins Science Center, Fort Collins, CO

Resolving concerns regarding energy types, development, and a secure energy future are high priorities for the current administration with emphasized focus by the Department of Interior. Land management agencies within DOI, in particular the Bureau of Land Management, must contend with balancing energy development with other land uses and values. Such decisions are often controversial and complex, necessitating easy access to useful data, literature and on-line resources that facilitate better understanding of various effects from energy development. While there are several valuable on-line resources, these are spread across numerous websites and are often focused on only a few key components (e.g. oil and gas literature; wind energy and wildlife; etc.). Development of a web-based energy resource database comprised of pertinent foundational and current literature citations, links to relevant energy related on-line resources and research efforts would provide USGS researchers and collaborators an efficient mechanism to access the latest data and research references. Seeing the need for such an effort, the Wyoming Landscape Conservation Initiative has funded the development of the Western Energy Citation Clearinghouse or WECC. The key objective of this effort is to develop a web-based literature citation database of research that can be easily queried to serve as a “clearinghouse” of key literature and on-line resources for energy, energy development, and associated effects on the landscape. The database will be a ‘living’ database in that it will be continuously reviewed and updated in order to provide the most up-to-date resources. Through extensive collaboration across disciplines and thorough literature searches fundamental foundational and current literature to include in the database will be identified. Links to other useful literature databases and websites are also identified for easy access.

Jessica M. Montag, USGS Fort Collins Science Center, 2150 Centre Ave., Bldg. C, Fort Collins, CO 80526-8118, Email: montagj@usgs.gov.

Energy Map of Southwestern Wyoming: Energy Data Archived, Organized, and Accessible

Laura R.H. Biewick, USGS Central Energy Resources Science Center, Denver, CO, Nicholas R. Jones, University of Wyoming Enhanced Oil Recovery Institute, Laramie, WY and Anna B. Wilson, USGS Central Mineral and Environmental Resources Science Center, Denver, CO

To help drive sound energy resource decisions, geologic information needs to be adequately archived, organized, and published in a manner that provides easily accessible information via Geographic Information Systems (GIS) and other research-related software for use by a variety of disciplines. The U.S. Geological Survey (USGS) has a long standing program assessing energy resources, including coal, gas, oil, uranium, and geothermal, as well as assessing environmental and health effects of the development and utilization of these resources. The accumulated data representing decades of research by the USGS are complimented by the results of similar activities by the Wyoming State Geological Survey, the U.S. Bureau of Land Management, industry and others, and all have been assembled into one geodatabase. The Energy Map of Southwestern Wyoming, prepared in two parts, is designed to facilitate a landscape-level approach to

multidisciplinary science assessments, and science-based resource management decision-making. Part A contains data associated with the electrical power sources of coal and wind, and is here presented orally and as a poster session. The discussion includes (1) coal fields in this and surrounding areas, (2) the Laramide Orogeny and the paleogeography that determined the sites of coal accumulation during the Late Cretaceous and early Tertiary time, (3) energy resource assessments, and (4) wind resources and wind farms. Part B is in progress and will include oil, gas, uranium and solar resource information, as well as related features including infrastructure associated with exploration, production and development, and the extent and nature of restrictions or impediments to energy resources development.

Laura R.H. Biewick, USGS Central Energy Resources Science Center, Box 25046, Denver Federal Center, Denver, CO 80225-0046, Email: lbiewick@usgs.gov.

Mineral Resources of the Wyoming Landscape Conservation Initiative (WLCI) study area—Past, present, and future

Anna B. Wilson, USGS Central Mineral and Environmental Resources Science Center, Denver, CO

Historically, mining has been a major and diverse industry in southwest Wyoming, but in recent years only a few mineral resources (other than coal) are actively being sought or exploited. Within the Wyoming Landscape Conservation Initiative (WLCI), there are 16 districts, covering less than 20% of the total study area, where interest in mineral resources is, or has been, concentrated. Current significant mining activity in the WLCI is focused in only 3 of the 16 regions for trona (soda ash) and uranium. Near-future activity, although uncertain, is likely to be sought on a large-scale for only trona and uranium. Other industrial minerals, such as sand and gravel, stone, gypsum, and barite, etc. are not included in this study. The world's largest trona deposit (covering almost 3,600 km²), located in the southwestern part of WLCI, remains an economically viable commodity in today's market. Uranium exploration was intense from the late 1950s into the 1970s, with activity in Ketchum Buttes, Poison Basin, Crooks Gap-Green Mountain, Shirley Basin, and Great Divide Basin. Today, the major mines in Crooks Gap-Green Mountain are either reclaimed or idle, Shirley Basin has been almost entirely reclaimed, and Ketchum Buttes appears abandoned, but there are proposed in-situ recovery projects being pursued in Great Divide Basin and Poison Basin. Most of the base- and precious-metals (including gold, silver, copper, lead, and zinc resources) in the Lake Alice, Encampment, Seminoe, Iron Formation NE, Big Creek, Cooper Hill, Gold Hill, Herman, and Keystone districts were first explored and developed in the late 1800s and abandoned by the early 1900s. Some of them were re-explored or reactivated in the World War II era. Only a few were active in the 1970s to 1980s and nearly all have been abandoned. All the phosphate mines (for example, Leefe and South Mountain) and prospects in the western part of the study area appear to have been either abandoned or reclaimed.

Anna B. Wilson, USGS Central Mineral and Environmental Resources Science Center, Box 25046, Denver Federal Center, Denver, CO 80225-0046, Email: awilson@usgs.gov.

Session II. Understanding the Influence of Land Use and Energy Development on Wildlife Populations and Their Habitats

Wildlife in southwestern Wyoming are facing unprecedented changes in their habitat as a result of land use and expanded energy development. In this session, we explore some of the changes that are occurring to both terrestrial and aquatic species, their habitats and life histories. We will also explore how biologists are using information from species and habitat surveys to build databases and develop new analysis tools and models that will help managers to mitigate land use impacts and to develop sound conservation and restoration practices.

Oral Presentations

Session II A. Energy Development, Life History, and Movements of Large Ungulates.

Assessing the Relative Exposure to Development for Wyoming's Species of Greatest Conservation Need.

Douglas Keinath, University of Wyoming, Wyoming Natural Diversity Database, Laramie, WY; **Matthew Kauffman**, Wyoming Cooperative Fish and Wildlife Research Unit, Laramie, WY; **Daniel Doak**, University of Wyoming, Department of Zoology and Physiology, Laramie, WY; **Holly Copeland**, and **Amy Pocewicz**, The Nature Conservancy, Lander, WY; **Mark Andersen**, University of Wyoming, Wyoming Natural Diversity Database, Laramie, WY.

The current revision of Wyoming's State Wildlife Action Plan (SWAP) lists over 150 vertebrate species as being Species of Greatest Conservation Need (SGCN), over 80% of which have more than half their Wyoming range assumed in the absence of verified survey data. In 2010, we presented species distribution models for all SGCN, which are now in use by many state agencies and non-profit organizations. Since then, we have mapped projected distribution of oil, natural gas and wind-power activities and calculated the relative exposure of all SGCN to these activities. Exposure represents how extensively the predicted suitable habitat occurs in proximity to expected development. Preliminary calculations indicate that the top 5 most exposed species are (in decreasing order of exposure): Great Plains Toad, Rocky Mountain Toad, Black-tailed Prairie Dog, Pygmy Rabbit and Wyoming Pocket Gopher. Oil and gas development is the principle route of exposure for each of these species. In contrast, Black-footed Ferret is likely to be most the most exposed SGCN to wind power development, and this exposure is sufficient to make it the sixth most exposed species overall.

Doug Keinath, Wyoming Natural Diversity Database, 1000 E. University Ave., Dept. 3381, University of Wyoming, Laramie, WY, 82071. Email: dkeinath@uwyo.edu

Elk Seasonal Resource Selection Before and During Development of a Natural Gas Field.

Clay B. Buchanan and **Jeffrey L. Beck**, Department of Ecosystem Science and Management, University of Wyoming, Laramie, WY; **Thomas E. Bills**, BLM Buffalo Field Office, Buffalo, WY.

World energy demand is predicted to increase dramatically in the coming decades, suggesting the need to better understand the role of disturbance for affected wildlife populations. Our research focused on summer and winter elk (*Cervus elaphus*) response to disturbance risk associated with natural gas development, including mechanisms driving resource selection. Our study was based in the 500-km² Fortification Creek Area of northeastern Wyoming, USA where over 700 coal bed natural gas (CBNG) wells were developed. Elk monitoring in the Fortification Creek Area began in the mid-1990s, before CBNG development, providing us with a temporal control (1992–1995) to elk monitoring during development (2008–2010). Vehicle traffic levels were measured on different road types (e.g., access, link, and well roads) as a metric of CBNG development activity. We used environmental and CBNG development data to develop multiple regression models for summer and winter using 405 VHF locations from 17 cow elk prior to CBNG development and 112,549 GPS locations from 35 cow elk during CBNG development to assess spatial selection shifts. We created models for individual animals and averaged coefficients across individuals to build population level models during years of development. Comparison of elk resource selection before and during CBNG development demonstrated a distributional shift, whereby during development, elk used distance from infrastructure and escape cover to minimize risk. During development elk selected areas with greater conifer cover and away from CBNG roads. Variable coefficients suggest elk avoided development even where activity was low, such as producing well pads with visits limited to maintenance personnel. Reducing traffic levels on both access and link roads could reduce indirect habitat loss by 50–70%. We suggest reducing the human presence surrounding CBNG development through new technologies such as telemetered wells and sustaining undeveloped areas within the development footprint to maintain elk refugia.

Clay B. Buchanan, Department of Ecosystem Science and Management, University of Wyoming, Laramie, WY 82071, USA. Email: cbuchan1@uwyo.edu.

Evaluating the Influence of Development on Ungulate Migrations.

Teal B. Wyckoff, Wyoming Cooperative Fish and Wildlife Research Unit and the Wyoming Geographic Information Science Center, University of Wyoming, Laramie, WY; **Matthew J. Kauffman**, USGS, Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming, Laramie, WY; **Steven L. Garman**, USGS Rocky Mountain Geographic Science Center, Denver, CO; **Jamie L. McBeth**, USGS Rocky Mountain Geographic Science Center, Bozeman, MT.

Migratory ungulates are declining globally, due in large part to anthropogenic disturbance of their migration corridors. Although ungulates can behaviorally adapt to some types of development, the consequences of such behaviors for population performance are unclear. In addition, it is unknown if migration route persistence declines beyond some threshold level of development. We are evaluating the influence of development intensity on the migratory behavior of several western Wyoming ungulate populations. These migration routes span a gradient of development, from pristine wilderness to suburban housing, to habitats intensively developed for energy extraction. We are currently analyzing GPS movement data collected during existing studies on mule deer. We measured for each route: rate of travel through developed areas and rate of travel through undeveloped areas over multiple years representing increasing levels of development, and

spring and fall initiation dates. With these migratory behaviors measured for each animal, we then assessed whether such behaviors differed as a function of the level of development occurring along the route by evaluating differences between movement behavior and stopover use in disturbed habitat with high levels of human activity, compared to relatively pristine habitat, with little human activity or disturbance. Our preliminary findings indicate that with increasing levels of development, migrating ungulates alter their behavior to limit their exposure to developed areas. In particular, we found that animals sped up when migrating through developed areas, a behavior that likely diminishes foraging opportunities associated with stopover sites. Study findings will aid the conservation of ungulate migration routes and stopover sites by identifying how landscape connectivity is impeded by development, while furthering our basic understanding of migration ecology.

Teal B. Wyckoff, Wyoming Cooperative Fish and Wildlife Research Unit and the Wyoming Geographic Information Science Center, Departments 3166 and 4008, 1000 East University Avenue, Laramie, WY 82071. Email: Wyckoff@uwyo.edu.

Pronghorn Response to Wind Energy Development on Winter Range in South Central, Wyoming.

Katie Taylor and Jeffrey L. Beck, Department of Ecosystem Science and Management, University of Wyoming, Laramie, WY.

The U. S. Department of Energy recently proposed that 20% of the electricity generated in the United States will be supplied by wind energy by 2030. Landscapes with high potential for wind energy development often coincide with suitable wintering habitat for pronghorn (*Antilocapra americana*) where forage is made available by continuously blowing snow. Evaluating the influence of energy development to pronghorn on winter range is particularly critical given that they encounter elevated energetic demands during this time of year. Our study is designed as an impact-reference study, where the effects of wind energy infrastructure on wintering pronghorn are being evaluated at the Dunlap Ranch (DR) impact study area in the Shirley Basin, Wyoming. Our non-impacted reference study area is south of Walcott Junction (WJ), Wyoming. The goals of our study are to compare resource selection and survival for pronghorn that encounter wind energy infrastructure (DR) compared to pronghorn that do not (WJ) over 3 winters (2010, 2010–2011, and 2011–2012). Specific objectives of our study are to 1) use resource selection functions to model, identify, and compare landscape features (anthropogenic and environmental) that best predict pronghorn winter habitat use for each winter on the DR and WJ, 2) evaluate the displacement of pronghorn at DR by wind energy infrastructure components (turbines, access roads, transmission lines, substations), and 3) model survival risk for pronghorn and compare differences in risk based on environmental and anthropogenic variables that influence survival on the DR and WJ. In January 2010 we captured and attached GPS-transmitters to 70 doe pronghorn (35 in the DR and 35 in the WJ). We have been monitoring these animals via fixed-wing flights approximately 5 times per year and have recovered location data from 32 dead pronghorn. The remaining GPS collars will deploy after May 2012.

Katie L. Taylor, University of Wyoming, Dept. 3354, 1000 E. University Ave, Laramie, WY, 82071. Email: ktaylor21@uwyo.edu.

Mule Deer Migration and Energy Development: An Update on WLCI Research.

Hall Sawyer, Western Ecosystems Technology, Inc., Laramie, WY; **Matt Kauffman**, USGS, Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming, Laramie, WY.

As habitat loss and fragmentation increase across ungulate ranges, identifying and prioritizing migration routes for land-use planning and conservation has taken on a new urgency. The Wyoming Cooperative Fish and Wildlife Research Unit has been partially funded by WLCI to conduct research on the influence of energy development on mule deer, including their seasonal migrations. In an initial phase of this work, we created a general framework to map and identify migration routes with the highest conservation value within a route network. This approach has been applied to migratory mule deer populations that winter near the Atlantic Rim and Pinedale Anticline Project Areas. In addition to identifying key migration corridors for conservation and enhancement, these analyses identified the consistent use of stopover areas by migrating deer, similar to what has been found in long-distance migrations of avian taxa. In a second study, we found that mule deer migrating through undisturbed habitat spent considerable time (95% of their 3-week long migrations) stopping over to forage in identified habitat patches. This work suggests that migrating ungulates derive considerable foraging benefit from the habitats through which they migrate. Our research program has clarified the benefits that deer receive from migrating and will allow a more accurate characterization of the influence of energy development on these seasonal movements. In addition to this research overview, future management and research needs will be discussed.

Matt Kauffman, USGS Wyoming Cooperative Fish and Wildlife Research Unit, Department of Zoology and Physiology, University of Wyoming, Laramie, WY. Email: mkaufm1@uwyo.edu.

Session II B. Energy Development, Life History, and Habitats of Birds, Fish, and Small Mammals.

Songbirds and Energy Development: Patterns and Mechanisms.

Anna D. Chalfoun, USGS Wyoming Cooperative Fish and Wildlife Research Unit, Department of Zoology and Physiology, University of Wyoming, Laramie, WY; **Michelle M. Gilbert** and **Matthew G. Hethcoat**, Department of Zoology and Physiology, University of Wyoming, Laramie, WY.

Inevitable impacts of energy development activities include conversion and fragmentation of wildlife habitat as well as alteration of remaining patches. Understanding how and why wildlife populations are impacted by such changes is critical for wildlife conservation in the face of a rapidly expanding energy development industry. We examined the abundance of breeding sagebrush songbirds, many of which are displaying substantial range-wide declines, with respect to the density of natural gas wells in the Jonah and Pinedale Anticline fields in western Wyoming, USA. Increased well density was associated with significant decreases in Brewer's, sage, and vesper sparrow but not sage thrasher abundance. From a mechanistic standpoint, nestling masses for most species did not vary with energy development intensity, suggesting little evidence for changes in food availability. However, daily nest survival rates for all three sagebrush-obligate species decreased with well density and proximity to the nearest well

pad. Current work is focused on why nest predation rates increased with energy development. We are identifying nest predator species with infrared cameras and comparing predator abundance and diversity across energy development treatments. Understanding the mechanisms underlying energy development effects for songbirds and other species will greatly aid management prescriptions geared towards mitigating impacts of energy development to already declining species.

Anna D. Chalfoun, U.S. Geological Survey Wyoming Cooperative Fish and Wildlife Research Unit, Department of Zoology and Physiology (3166), University of Wyoming, 1000 E. University Avenue, Laramie, WY, 82071, Email: achalfou@uwyo.edu.

Identifying the Relationship between Natural Gas Energy Development and Pygmy Rabbit (*Brachylagus idahoensis*) Site Occupancy.

Steve Germaine, Jeff Kemper, USGS Fort Collins Science Center, Fort Collins, CO; Dale Woolwine, BLM Pinedale Field Office, Pinedale, WY; Drew Ignizio, Cherokee Services Group, Fort Collins, CO.

More than 2,200 mi² of land in southwestern Wyoming is currently covered by operational gas fields, and further development is projected for at least 25 years. Pygmy rabbits –a Wyoming Species of Greatest Conservation Need– may be more heavily impacted by energy development in southwestern Wyoming than anywhere else in their occupied range, but little information exists on the relationship between gas field development and pygmy rabbits. To address this need, we began two studies to examine the relationship between gas field development and pygmy rabbit site occupancy patterns. The first is on the Normally Pressurized Lance (NPL) gas field in Sublette County, which is scheduled for development beginning in 2014, and may have up to 3,500 gas wells operational in a 220 mi² area by 2024. In 2010, we began conducting pre-development site occupancy surveys for pygmy rabbits at 150 plots distributed evenly across the NPL and three adjacent control areas using a Before – After – Control – Impact (B-A-C-I) design. Power analysis indicates that our design is sufficient to detect a 35% change in occupancy in control versus NPL after development. Second, in 2011 we began evaluating the influence of gas field development density on pygmy rabbit site occupancy rates on the Atlantic Rim, Jonah, and PAPA gas fields. Using digital gas well data, NAIP imagery, and the WYNDD pygmy rabbit habitat map in Arc/Info, we located ≥ 26 survey plots in suitable pygmy rabbit habitat on each gas field, where plots spanned a gradient of gas well density ranging from zero to the maximum density present. We surveyed each plot for pygmy rabbit sign twice during summer of 2011, and are modeling plot occupancy status as a function of gas well, well pad, and road density. Occupancy trends based on year one of data collection will be presented. Over two additional years of sampling, we will attempt to identify development density thresholds above which pygmy rabbit site occupancy rates are adversely affected.

Steve Germaine, USGS Fort Collins Science Center, 2150 Centre Ave, Bldg C, Fort Collins, CO 80526. Email: germaines@usgs.gov.

Burrowing Owl Nest Predictive Modeling for the Normally Pressured Lance (NPL) Project Area.

John Dahlke and **Matt Holloran**, Wyoming Wildlife Consultants LLC, Pinedale, WY.

Burrowing Owls are a species of conservation concern across the western United States and western Canada; large-scale survey efforts suggest that populations have declined across this region since the mid-1960s. Burrowing Owls present a unique challenge to managers applying standard on-site mitigation restrictions to natural gas developments (e.g., No Surface Occupancy and timing limitations around active raptor nests) because of year-to-year inconsistency in the locations of nesting territories selected by the species. In the Jonah II project area, drilling schedules developed by industry have often been disrupted by the presence of Burrowing Owls located during individual well clearance surveys. The overall goal of this proposed project is to develop habitat selection models capable of predicting locations of nesting Burrowing Owls in the subsequent year given conditions measured in the current year. These predictions could be used to reduce energy development conflicts with Burrowing Owls and subsequently reduce disruptions and interruptions to drilling schedules. Unlike most other raptors within SW Wyoming that nest on relatively unique, permanent substrates (i.e., cliffs, trees and outcrops), Burrowing Owls nest in holes dug by fossorial mammals; these sites are ephemeral with a limited life-span. Further, most of the extant information on Burrowing Owls is from areas where the species maintains a close association with black-tailed prairie dogs. The level of Burrowing Owl association with white-tailed prairie dogs--the species occurring within the WLCI area--is unknown. Differences in the biology of black-tailed vs. white-tailed prairie dogs and their habitats result in Burrowing Owls not being restricted to defined and mapped prairie dog towns in SW Wyoming. The pattern of extant data for the NPL and Jonah II project areas supports the thesis that suitable habitat associations for Burrowing Owls in SW Wyoming are provided by a variety of fossorial animal species in addition to prairie dogs; 48% (45/94) of all records from this area in the BLM database were not associated with mapped prairie dog towns. This lack of association biases the effectiveness of current surveys and potential mitigation considerations.

Matt Holloran, Wyoming Wildlife Consultants LLC, P.O. Box 893, Pinedale, WY 82941. Email: matth@wyowildlife.com.

Modeling Concentration Areas for Migratory Birds in Wyoming.

Amy Pocewicz, The Nature Conservancy, Lander, WY; Wendy Estes-Zumpf, Mark Andersen, Doug Keinath, Wyoming Natural Diversity Database, Laramie, WY; Holly Copeland, The Nature Conservancy, Lander, WY.

Bird mortality can be greatly reduced if wind energy facilities avoid major migration stopovers and pathways, or implement designs to reduce bird impacts. However, there is a need to identify where these migratory concentration areas are located. In Wyoming, information on the occurrence and ecology of migratory bird species is spread throughout an array of sources, ranging from incidental sightings, migration counts, formal and informal reports, scientific studies, and expert knowledge of particular species. The lack of a concise synthesis of information on migratory birds severely limits the ability of agencies and companies to incorporate this critical knowledge into wind development planning. Our objective was to map migratory bird concentration areas across Wyoming

and identify potential conflicts with wind development. Bird species that tend to concentrate migration along narrow routes and at specific stopover areas are the species at highest risk to repeated mortalities from wind turbines. Thus, these “concentrated migrant” species are the focus of this migration mapping project and fall into four general categories: raptors, wetland birds, riparian birds, and sparse grassland birds. Specific information about how typical migrants in each group utilize and fly between stopover areas was based on an extensive literature review and used to develop conceptual models of migration concentration. These conceptual models were validated through expert review and known migration locations. We also modeled where future wind energy development is most likely to occur. Our findings highlight where wind energy facilities may have the least and greatest impacts on migratory birds and where knowledge gaps about migration remain.

Amy Pocerwicz, The Nature Conservancy, 258 Main St., Lander, WY 82520, Email: apocerwicz@tnc.org

Spatial Variation in the Isotopic Niche of Freshwater Fishes in the Bear River Drainage, Great Basin, USA.

Mark C. Belk, and Jeff Wesner, Brigham Young University, Provo, UT.

We characterized spatial variation in the isotopic niche of four freshwater fish species native to the Great Basin, USA. We also asked how the trophic position of two common species (reidside shiner *Richardsonius balteatus* and speckled dace *Rhinichthys osculus*) varied across sites with and without a rare biodiversity indicator, northern leatherside chub (*Lepidomeda copei*). Preliminary results from five sites within the Bear River drainage suggest that species' resource use ($\delta^{13}\text{C}$) and trophic position ($\delta^{15}\text{N}$) varied across sites, though the relative position of fishes to each other remained similar. At sites with northern leatherside chub, reidside shiners and speckled dace showed 2-5% enrichment in $\delta^{15}\text{N}$, indicating a trophic level increase. Reidside shiners and northern leatherside chub were isotopically indistinguishable, indicating no evidence of niche displacement, despite apparent ecological similarity of these two species. These preliminary results suggest that the absence of northern leatherside chub, which were once common in this drainage, may correlate to subtle changes in the overall food web. We will discuss possible mechanisms behind these preliminary patterns.

Mark C. Belk, 401 WIDB Department of Biology Brigham Young University, Provo UT. 84602 USA, Email: mark_belk@byu.edu

Session II C. Greater Sage-Grouse and Human Development

Across Space and Time: Seasonal and Regional Variation in Habitat Selection of Greater Sage-Grouse across Large Spatial Scales.

Brad Fedy and Cameron Aldridge, Natural Resources Ecology Laboratory, Colorado State University and US Geological Survey, Ft. Collins, CO., Kevin Doherty, US Fish and Wildlife Service, Bismarck, ND., Michael O'Donnell, ASRC Management Services, Ft. Collins, CO., Jeffrey Beck and Christopher Kirol, University of Wyoming, Laramie, WY., Bryan Bedrosian, Craighead Beringia South, Kelly, WY., Matthew Holloran, Wyoming Wildlife Consultants, LLC, Pinedale, WY., David Marshall, Harvey

Environmental, LLC, Bozeman, MT., Gwyn McKee, Thunderbird Wildlife Consulting, Inc., Gillette, WY., Cheryl Mandich, University of Wyoming Casper Center, Casper, WY., Chad Olson, Hayden Wing Associates, LLC, Laramie, WY., Gregory Johnson, Western Ecosystems Technology, Inc., Cheyenne, WY., Nicholas Kaczor, US Fish and Wildlife Service, Lakewood, CO., Chris Swanson, US Fish and Wildlife Service, Kulm, ND., and Brett Walker, Colorado Division of Wildlife, Grand Junction, CO.

Defining and understanding animal-habitat relationships is a fundamental concept in ecology and important to the implementation of conservation practices. Habitat relationships are often described for animal species during a single life stage and within a single region. However, animals typically require different habitats throughout their annual cycles and relationships may vary across landscapes. Greater sage-grouse (*Centrocercus urophasianus* hereafter sage-grouse) have been extirpated from nearly half of their original range in western North America, and Wyoming is predicted to remain one of the strongholds for populations. Sage-grouse require an adequate amount, configuration, and juxtaposition of all seasonal habitats for populations to persist. We developed state-wide seasonally explicit habitat selection models to help identify and delineate suitable seasonal habitats. We also quantified regional variation in habitat selection behavior. We compiled extensive radio-telemetry data from 11 sites across Wyoming (n = 3,000 individuals). We used these telemetry data, in combination with high-quality GIS data, to develop seasonal habitat selection models for sage-grouse across Wyoming. We developed models at patch and landscape extents for three separate life stages: 1) nesting, 2) summer/late brood-rearing, and 3) winter habitat. The state-wide models performed well; however, we also assessed regional variation in habitat selection behaviour. We divided Wyoming into three regions and developed all seasonal models on a regional basis. We quantified variation in model form and the strength of selection for certain habitat components. Furthermore, we quantified the variation in model accuracy and precision between the state-wide and regional models to assess the value added by the regional approach.

Bradley C. Fedy, Colorado State University and the U.S. Geological Survey, Fort Collins Science Center, 2150 Center Avenue, Bldg. C, Fort Collins, CO, 80526, Email: fedyb@usgs.gov.

Greater Sage-Grouse Select Nest Sites and Brood Sites Away from Avian Predators.

Jonathan B. Dinkins and Michael R. Conover, Department of Wildland Resources, Utah State University, Logan, UT; Christopher P. Kirol and Jeffrey L. Beck, Department of Ecosystem Science and Management, University of Wyoming, Laramie, WY.

Greater Sage-Grouse (*Centrocercus urophasianus*; hereafter “sage-grouse”) distribution and abundance in western North America has declined over the last century. Depredation of sage-grouse nests and predation of chicks can be one of the most influential factors limiting their productivity. Prey species utilize anti-predation behaviors, such as predator avoidance, to reduce the risk of predation. Birds in general balance the dual necessity of selecting cover to hide from visual and olfactory predators to optimize their survival and reproductive success (optimal-hiding strategy), which may also be achieved by selecting habitat with relatively fewer predators. We compared avian predator densities at sage-grouse nests and brood locations to random locations within available sage-grouse habitat. This comparison allowed us to assess the ability of sage-grouse to avoid avian predators during nesting and early brood-rearing. During 2008–2010, we conducted 10-

min point-count surveys at 218 sage-grouse nests, 249 sage-grouse brood locations from 83 sage-grouse broods, and 496 random locations. We found that random locations had higher densities of avian predators relative to sage-grouse nest and brood locations. Sage-grouse nested in areas where there were lower densities of Common Ravens (*Corvus corax*), Black-billed Magpies (*Pica hudsonia*), Golden Eagles (*Aquila chrysaetos*), and Buteo hawks compared to random locations. Additionally, sage-grouse selected brood-rearing locations that had lower densities of the same avian predators as during nesting plus American Kestrels (*Falco sparverius*) compared to random. By selecting nest and brood-rearing locations with lower avian predator densities, sage-grouse may reduce the risk of nest depredation and predation on eggs, chicks, and hens.

Jonathan B. Dinkins, Department of Wildland Resources, Utah State University, Logan, UT 84322-5230, Email: jon.dinkins@aggiemail.usu.edu.

Greater Sage-Grouse Winter Habitat Selection in South-Central, Wyoming: Response to Anthropogenic and Environmental Factors Characterizing Winter Habitat.

Jeffrey L. Beck, Jennifer E. Hess, Kurt T. Smith, and Christopher P. Kirol, Department of Ecosystem Science and Management, University of Wyoming, Laramie, WY; Frank C. Blomquist, BLM Rawlins Field Office, Rawlins, WY.

Modeling habitat selection is critical to inform conservation efforts for wildlife populations that winter in areas undergoing energy development. We compared winter habitat selection patterns for female greater sage-grouse (*Centrocercus urophasianus*) inhabiting a 6,979 km² study area with coalbed natural gas (CBNG) extraction that straddled northwestern Colorado and south-central Wyoming, USA and a 1,546 km² reference study area lacking energy development in south-central Wyoming, USA. Our objectives were to: 1) identify landscape characteristics that influenced winter habitat selection and 2) evaluate whether CBNG infrastructure influenced selection. We used 1,025 locations from radio-marked birds obtained from 34 fixed-wing flights across 3 winters (2007–2008, 2008–2009, and 2009–2010) in binary logistic regression modeling to quantify selection by comparing grouse and available locations at 3 spatial scales (490 m, 1,226 m, and 2,451 m radii) based on location error and 7 and 14 day movements, respectively. We used 13 landscape predictor variables including anthropogenic infrastructure, snow accumulation, topography, and vegetation in our analysis. Environmental variables that influenced grouse habitat selection in the CBNG study area included greater variability in shrub height and lesser variability in sagebrush cover within 2,451 m, areas with greater sagebrush cover within 1,226 m, and areas with lesser topographic ruggedness and greater topographic wetness within 490 m compared to random locations. Anthropogenic variables influencing winter grouse habitat selection in the CBNG study area included road effects within 2,451 m compared to random locations. Grouse in our reference study area selected winter habitat with lower topographic ruggedness within 490 m and greater sagebrush cover and lesser variability in sagebrush cover within 2,451 m compared to random locations. Our results indicate the importance of conserving large sagebrush landscapes for wintering sage-grouse that are characterized by low-to-moderate relief, variable shrub height, high sagebrush cover, and in areas with few roads.

Short-Term Impacts to Greater Sage-Grouse from Wind Energy Development.

Chad W. LeBeau and Jeffrey L. Beck, University of Wyoming, Laramie, WY; Greg D. Johnson and Ryan Nielson, WEST, Inc., Cheyenne, WY; Matt Holloran, Wyoming Wildlife Consultants, Pinedale, WY.

Wind energy development is increasing in rangeland habitats, which has raised concerns relative to impacts to avian species including the Greater Sage-Grouse (*Centrocercus urophasianus*; hereafter sage-grouse). Little information exists about the impacts of wind energy development on sage-grouse; however, wind energy infrastructure is likely to directly and indirectly impact sage-grouse movements because they avoid tall structures and human activities. Changing movements may equate to different habitat selection patterns, which are predicted to lead to reduced population fitness. The purpose of our study was to document habitat occurrence and fitness parameters associated with sage-grouse inhabiting areas in close proximity to wind turbines. In April 2009 and 2010, we captured 116 female sage-grouse near Medicine Bow, Wyoming and have monitored these grouse for 2 years to evaluate nest, brood, and female survival, and habitat occurrence. We used logistic regression to develop resource selection functions to estimate habitat occurrence. We used Cox proportional hazards regression to model nest, brood and female survival. The proximity to wind turbines did not influence nest site or brood-rearing occurrence but the relative probability of summer occurrence increased in habitats closer to wind turbines. Female survival was not influenced by wind turbines but nest and brood survival were both negatively affected by proximity to wind turbines. This is the first study to evaluate short-term effects of wind energy infrastructure--specifically wind turbines--on sage-grouse fitness parameters and habitat selection.

Chad W. LeBeau, University of Wyoming, 1000 E University Ave, Laramie, WY, 82071, Email: cwlebeau@west-inc.com.

Modeling Greater Sage-Grouse Source and Sink Habitats in a Developing Coalbed Natural Gas Field in South-Central Wyoming.

Christopher P. Kirol, Jeffrey L. Beck, Department of Ecosystem Science and Management, University of Wyoming, Laramie, WY; Snehalata V. Huzurbazar, Department of Statistics, University of Wyoming, Laramie, WY; Frank C. Blomquist, BLM Rawlins Field Office, Rawlins, WY.

Our objective was to model source and sink habitats for greater sage-grouse (*Centrocercus urophasianus*) in the 1,093 km² Atlantic Rim Project Area (ARPA) of south-central, Wyoming, which is being developed for coalbed natural gas (CBNG). We coupled habitat selection and survival models using data from n = 167 female grouse collected in May–August 2008 and 2009. To predict habitat selection, we evaluated relationships between landscape scale environmental and anthropogenic covariates, at 0.25-km, 1-km, and 5-km scales using binary logistic regression to identify the most predictive model combinations to produce resource selection functions (RSFs) for nesting, early and late brood-rearing, and for broodless hens in early and late summer. We combined the RSF's for each life-stage to form an occurrence layer that spatially

identified areas with the highest and lowest relative probability of use in summer. We used proportional hazards modeling to identify the most predictive models for nest, brood, and adult female summer survival to predict survival based on the same landscape covariates and scales that we termed survival probability functions (SPFs). We combined SPF's into a lambda equation that was mapped on the ARPA to predict habitats that contributed to population sources or sinks. Finally, the occurrence layer and lambda layer were combined to predict selected and non-selected source and sink habitats. Our analysis indicated that 40% of the ARPA was selected-source while 4% was selected-sink habitat. Our results suggest that the primary concern of CBNG development on sage-grouse population persistence in the ARPA is avoidance of otherwise productive habitats. That is, selected-source becoming nonselected-source in habitats with CBNG development. By predicting sink and source habitats we identified areas that should take conservation priority during development to maintain a viable sage-grouse population in the ARPA and a method that can be used in other energy development landscapes.

Christopher P. Kirol, University of Wyoming, Dept 3354, 1000 East University Avenue, Laramie, WY 82071, Email: ckrol@uwyo.edu.

Session II D. Inventory and Modeling Tools and Conservation of Greater Sage-Grouse in SW Wyoming

Map and Inventory Water Resources to Help Create a Sage-Grouse Brood-Rearing Model in Order to Influence Management Decisions.

Erik E. Norelius, Lawrence W. Ashton III, Jerry A. Pierce, and Ronald L. Mitchell, BLM Kemmerer Field Office, Kemmerer, WY.

In order to maintain wildlife habitats, natural resource professionals need to consider all aspects of the life cycle and the habitats related to those life stages. We began by mapping and inventorying springs, seeps and reservoirs in a portion of the Wyoming Governor's Sage Grouse Core Areas (as defined by the executive order (EO 2011-05)) in southwestern Wyoming. After late summer and fall data collection, the data was analyzed and combined with Wyoming Game and Fish Department (WGFD) observation information and United States Geologic Survey (USGS) sagebrush maps to create a brood-rearing model. The model is being used and is combined with best available science to influence future land management decisions.

Erik E. Norelius, U.S. Department of Interior Bureau of Land Management, Kemmerer Field Office, 312 Highway 189 North, Kemmerer, WY, 83101, Email: enoreliu@blm.gov.

Implementing Wyoming's Sage-Grouse Core Area Strategy via the Density and Disturbance Calculation Tool (DDCT) – Swinging a Dead Cat?

Tom Christiansen, Wyoming Game & Fish Department, Green River, WY; Chris Keefe, Travis Bargsten, BLM Wyoming State Office, Cheyenne, WY; Nyssa Whitford, Wyoming Game & Fish Department, Lander, WY; Sydney Thielke, BLM Lander Field Office, Lander, WY; Mary Flanderka, Wyoming Game & Fish Department Headquarters Office, Cheyenne, WY; Amanda Losch, Wyoming Game & Fish Department, Casper,

WY; and Jim Oakleaf, University of Wyoming, Wyoming Geographic Information Science Center, Laramie, WY.

In June 2011, Wyoming Governor Matt Mead issued Executive Order 2011-5 “Greater Sage-Grouse Core Area Protection”. This Executive Order replaced, but essentially reaffirmed, former Governor Freudenthal’s Executive Order 2010-4. This strategy is designed to address the U.S. Fish and Wildlife Service’s 2010 finding that the Greater Sage-Grouse (*Centrocercus urophasianus*) is a candidate for listing under the Endangered Species Act. The Service determined that habitat loss and fragmentation and the lack of sufficient regulatory mechanisms supported their finding. The Wyoming core area strategy is designed to address both of these listing factors. A key component of the core area strategy is limiting the density and amount of anthropogenic disturbance allowed within core areas. A process was developed by agency personnel and the Governor’s Sage-Grouse Implementation Team to evaluate proposed anthropogenic projects to determine if the project, together with existing disturbance, exceeds thresholds established by the Executive Order. Projects that result in the thresholds being exceeded are to be rejected, modified, or mitigated. The Density/Disturbance Calculation Tool (DDCT) is the mechanism by which levels of anthropogenic disturbance is determined and compared to the established thresholds. The DDCT process results in better planning and design as project proponents strive to minimize disturbance to stay within the thresholds allowed. A demonstration of the DDCT process will be presented.

Tom Christiansen, Wyoming Game and Fish Department, 351 Astle Ave., Green River, WY, 82935, Email: tom.christiansen@wyo.gov.

Collection, Assemblage and Population of a Sagebrush Treatment Geodatabase in Wyoming Sage-grouse Core Areas for the Wyoming Game and Fish Department.

Morgan W. Graham and Sean Beckett, Conservation Research Center, Teton Science Schools, Jackson, WY.

In summer of 2011, the Wyoming Game and Fish Department (WGFD) contracted the Conservation Research Center of Teton Science Schools (TSS) to collect, assemble and populate a geodatabase of historic sagebrush treatments. The scope of the project was limited to treatments or disturbances on federal and state lands within sage-grouse core areas. Treatments were defined as any sagebrush manipulation of 10 acres or larger. Disturbance included wildfires, prescribed burns, and chemical/mechanical thinning. The purpose of this presentation will be: 1) To provide an overview of the data collection process. 2) To report summary statistics on sagebrush disturbance in sage-grouse core areas. 3) To demo the final geodatabase for use in landscape assessments.

Morgan W. Graham, Conservation Research Center of Teton Science Schools, 700 Coyote Canyon Road, Jackson, WY 83001, morgan.graham@tetonscience.org.

Poster Presentations

Effects of Wyoming Range Energy Development on Native Fish Communities.

Carlin Girard and Annika Walters, USGS, Wyoming Cooperative Fish and Wildlife Research Unit, University of Wyoming, Laramie, WY.

Wyoming has experienced a significant increase in energy development over the last two decades. Oil and gas extraction is currently occurring throughout the southern extent of the Wyoming Range, and proposed expansion to the northern portion threatens to undermine the area's ecological integrity and biodiversity. In the summer months of 2012 and 2013, we will assess the current and future effects of energy development on the fishes of the Wyoming Range. We hypothesize that the structure of fish assemblages relates to habitat conditions which may be altered by drilling practices and associated infrastructure. Ecological disturbances include but are not limited to: increased road densities and vehicle traffic; fragmentation of terrestrial and aquatic habitats; and pollution of air, water and soil. Large information gaps exist regarding the effects of these disturbances on aquatic ecosystems. By comparing fish assemblages, riparian condition, sedimentation rates, and water quality and quantity between active energy development sites and "undeveloped" sites we will evaluate the impacts of resource extraction on the fish communities of the Wyoming Range. "Undeveloped" sites will be chosen to intentionally include proposed drilling areas. This will benefit our study in two ways; first, it will allow us to forecast impacts related to oil and gas development in the future, and it will provide an excellent baseline data set for comparison post-drilling. Our overall goal is document current ecological impacts that are affecting fish assemblages as well as predict how future development will impact presently undisturbed areas.

Carlin Girard, U.S. Geological Survey Wyoming Cooperative Fish and Wildlife Research Unit, Department of Zoology and Physiology (3166), University of Wyoming, 1000 E. University Avenue, Laramie, WY, 82071. Email: awalters@usgs.gov.

Energy Development and Wildlife Monitoring Database Organization in Wyoming.

Hillary A. Walrath and Peter D. Stahl, Dept. of Ecosystem Science and Management, University of Wyoming, Laramie, WY.

This project is a joint effort by the Wyoming Department of Game and Fish, Department of Ecosystem Science and Management and Wyoming Natural Diversity Database at the University of Wyoming to collect, organize and centralize Wyoming energy-related wildlife monitoring data into a searchable database. State, federal and commercial agencies are required to observe and report the condition of specific wildlife species before an area can be used for energy development. However, once the data is collected, it is stored away within the agency conducting the survey. This data is not organized or available to other agencies for evaluation. Wildlife monitoring reports from the Buffalo Field Office of the Bureau of Land Management (BLM) were collected for this project. This data was gathered, organized, and used to create a database centralizing this information and making it available to other agencies. The database houses information on a wide variety of wildlife species found in Wyoming. It also houses spatial reference

data for the surveyed areas. Once this project is completed, all of the BLM offices' wildlife monitoring data will eventually be entered into the database. In the future, other agencies can participate by entering their data into the database. Not only will this transform the paper reports into digital copies, but it will increase communication and transfer of knowledge between agencies. Combining this information with data already collected by WYNDD will provide a central location for agencies to submit and find energy-related wildlife monitoring information in Wyoming.

Hillary A. Walrath, Dept. of Ecosystem Science and Management, University of Wyoming, 1000 E. University Ave, Laramie, 82071 Email: hjones10@uwyo.edu.

Natural Gas Development and Wildlife Mitigation in Wyoming: A Primer.

Anne C. Jakle, Ruckelshaus Institute of Environment and Natural Resources, University of Wyoming, Laramie, WY.

Wildlife mitigation strategies continue to evolve, and multiple agencies and stakeholder groups have their own terms, definitions, and notions of what constitute mitigation activities. This primer draws from both working and statutory knowledge to provide a common foundation of terms and understanding for what “mitigation” and its associated activities mean in the context of wildlife and natural gas development in Wyoming. As more wildlife mitigation projects are undertaken and completed in Wyoming and neighboring states, it will be important that stakeholders have a shared information base and speak a common language.

Anne C. Jakle, Ruckelshaus Institute of Environment and Natural Resources, University of Wyoming, 804 E. Fremont St., Laramie, WY 82070. Email: ajakle@uwyo.edu.

Common Raven Movement and Behavior Associated With Human Development in Southwestern Wyoming.

Scott Mabray, Utah State University, Logan, UT.

Common ravens (*Corvus corax*) have a long history of living near human development and thriving in human altered landscapes (Engel and Young 1992). The purpose of this study is to determine behavior of the common raven during winter months and if human development plays a major role in daily activity. The oil industry and livestock production are major resources in southwestern Wyoming. While they prove very beneficial to human development they also provide roosting and foraging opportunities for ravens. My study will focus on ravens benefiting from human development and will give insight to how they incorporate it into their behavior. The knowledge obtained through this study will give wildlife managers a better understanding of raven behavior and will in turn allow them to better resolve the conflicts between ravens and humans.

Scott Mabray, 5230 Old Main Hill, Utah State University, Logan, UT. 84322.
Email: stmabray@gmail.com.

Session III. Assessing Landscapes and Monitoring Change (tools, approaches, and methodologies)

This session will focus on the assessment and monitoring of landscape change to understand land-use effects on fish and wildlife habitat and populations. Assessment and Monitoring of land-use activities by Federal, State and local governments, academia and the private sector provide a landscape-level understanding of treatment effects, status and trends of ecological properties, and emerging patterns over a range of temporal scales that collectively facilitate responsible resource development and management decisions. An emphasis of this session is on the tools, methods, and approaches to assessment and monitoring on focal habitats: sagebrush, mountain shrub, aspen, limber pine, aquatic, and riparian; and also for water quality, and focused studies in specific watersheds and drainages.

Oral Presentations

Session III A. Concurrent Topic: Muddy Creek, Carbon County

Major Ion and Trace Element Characteristics of the Muddy Creek Watershed

Melanie L. Clark, USGS Wyoming Water Science Center, Cheyenne, WY; JoAnn M. Holloway, Carleton R. Bern, USGS Crustal Geophysics & Geochemistry Science Center, Denver, CO; Travis S. Schmidt, Fort Collins Science Center, Fort Collins, CO; Robert R. McDougal, USGS Crustal Geophysics & Geochemistry Science Center, Denver, CO.

The Muddy Creek watershed in southwest Wyoming has ongoing conventional and coalbed natural gas development. In response to concerns about effects of energy development on water resources, the U.S. Geological Survey has been sampling the water quality of Muddy Creek since 2006. Sampling has included fixed-site sampling at Muddy Creek stream-gaging stations to characterize seasonal and annual variability of major ions, selenium, and other trace elements. In addition, multi-discipline synoptic studies were conducted during 2010 and 2011 to characterize occurrence and distribution of these constituents in surface water, groundwater, soil, bed sediment, and aquatic and riparian insect samples in order to evaluate watershed processes. Water chemistry of the Muddy Creek watershed varies temporally and spatially. Total dissolved solids in Muddy Creek generally were inversely related to streamflow and ranged from 267 to 2,810 milligrams per liter during 2006–11. Selenium concentrations in Muddy Creek occasionally exceeded aquatic-life criteria and generally were largest during low-flow conditions. Results from the 2010 synoptic study indicated calcium and bicarbonate dominated the chemistry of Muddy Creek in the upper basin. In contrast, sodium and sulfate dominated the chemistry in the lower basin, in part due to differences in geology. Eastern tributaries to Muddy Creek generally were mixed magnesium, sodium, sulfate, and bicarbonate waters. Groundwater chemistry of flowing wells sampled during the 2011 synoptic study were dominated by sodium and bicarbonate, and generally had larger concentrations of trace elements that are more soluble under reduced conditions (such as barium and iron) compared to stream samples. In contrast, concentrations of other trace elements (such as arsenic and selenium) tended to be larger in stream samples compared to groundwater. Overall, results suggest that the dissolution of mineral salts at or near the

surface is an important process controlling the stream chemistry in the Muddy Creek watershed.

Melanie L. Clark, USGS Wyoming Water Science Center, 521 Progress Circle, Ste 6, Cheyenne, WY, 82007, Email: mlclark@usgs.gov.

Muddy Creek Biogeochemistry: Sources for Nutrients and Potential Ecosystem Impacts

JoAnn M. Holloway, USGS Crustal Geophysics & Geochemistry Science Center, Denver, CO; Craig A. Stricker, USGS Fort Collins Science Center, Fort Collins, CO; Melanie L. Clark, USGS Wyoming Water Science Center, Cheyenne, WY; Robert R. McDougal, USGS Crustal Geophysics & Geochemistry Science Center, Denver, CO.

Muddy Creek, part of the Upper Colorado River watershed, is a semi-arid catchment in a sagebrush steppe ecosystem. Muddy Creek flows throughout the year and includes both perennial and ephemeral tributaries. Primary land use includes livestock grazing, oil and gas development, and recreational activity. A synoptic watershed assessment was conducted in 2010 to determine areas within the watershed that are more susceptible to mobilization of trace elements that occur in soils forming on marine shale. Soil, stream sediment, and water samples were collected and analyzed for major elements and a suite of trace elements. Formation waters discharged from two wells within the watershed were sampled in 2011 to evaluate the potential contribution to surface water organic carbon, nitrogen species, and trace elements. Soil nutrients were present in low concentrations throughout the watershed, with the exception of the headwater sampling site. Muddy Creek sediments were also nutrient-poor, with low concentrations of organic carbon (<0.05 to 1.4 % C) and no detectable concentrations of nitrogen. Selenium (Se), which was primarily derived from the weathering of exposed shale, increased in concentration with organic carbon in stream sediments and in alluvial soils. This correlation is consistent with the binding of Se to organic matter. Soils that formed directly from Se-bearing shales did not exhibit this relationship between Se and organic carbon. The ratio of dissolved organic carbon to total dissolved nitrogen was greater than 20 (DOC; 280 to 840 $\mu\text{M C}$; TDN; 12-40 $\mu\text{M N}$). Groundwater collected from two wells did not have unusually elevated Se or DOC concentrations, but did have elevated inorganic nitrogen concentrations (60 $\mu\text{M N-NH}_4^+$ in Well 1, 13 $\mu\text{M N-NO}_3^-$ in Well 2) relative to stream concentrations ($(\text{N-NH}_4^+ + \text{N-NO}_3^-) < 4 \mu\text{M N}$). The introduction of groundwater with DOC:TDN ratios 0.8 to 1.5, where N is dominantly inorganic, to streams where N is dominantly organic can potentially result in the shift of stream ecosystems and the type of organic matter present.

JoAnn Holloway, USGS Crustal Geophysics & Geochemistry Science Center, Box 25046, Denver Federal Center, Denver, CO, 80225-0046, Email: jholloway@usgs.gov.

Trace Elements in the Muddy Creek Food Web Prior to Most Coalbed Natural Gas Development

Lusha Tronstad, and Wendy Estes-Zumpf, Wyoming Natural Diversity Database, University of Wyoming, Laramie, WY.

The Muddy Creek ecosystem is unique because the stream contains a distinctive fish assemblage, is physically degraded, and will soon be influenced by coalbed natural gas (CBNG) development. We attempted to separate the effects of existing physical degradation and impending oil and gas development by measuring trace element concentrations in the Muddy Creek food web prior to most energy development. To extract CBNG resources, groundwater must be pumped to the surface. Groundwater produced during CBNG development can contain high concentrations of trace elements and is often discharged into nearby water bodies. Trace elements in produced water can be taken up into food resources and transferred to higher trophic levels in the food web through predation. We collected animals from each trophic level in the Muddy Creek food web above and below impending CBNG inputs and measured tissues for trace element concentrations and $\delta^{15}\text{N}$ (trophic position). We regressed trophic position against trace element concentration for each organism to examine how trace elements moved through the food web. Aluminum and zinc concentrations in water exceeded chronic standards for aquatic life. Only selenium and mercury bioaccumulated in the Muddy Creek food web, while other trace elements bioaccumulated (peaked at intermediate trophic levels) or had similar concentrations throughout the food web. By understanding the Muddy Creek ecosystem now, land managers and developers can make informed decisions about management needs and potential mitigation efforts. Our study established baseline conditions in the Muddy Creek food web. We plan to repeat this study in 3-5 years after CBNG development has occurred to compare how trace elements are accumulating in the food web.

Lusha Tronstad, Wyoming Natural Diversity Database, Berry Ctr., 315, University of Wyoming, 1000E. University Ave., Laramie, WY 82071, Email: tronstad@uwyo.edu.

Development of Riparian Consumers as Indicators of Aquatically Derived Selenium in Muddy Creek, WY

Travis. S. Schmidt, USGS Fort Collins Science Center, Fort Collins, CO; Ruth E. Wolf, USGS Crustal Geophysics & Geochemistry Science Center, Denver, CO; Craig A. Strickler, USGS Fort Collins Science Center, Fort Collins, CO; JoAnn M. Holloway, Carleton R. Bern, USGS Crustal Geophysics & Geochemistry Science Center, Denver, CO; Melanie L. Clark, USGS Wyoming Water Science Center, Cheyenne, WY; Robert R. McDougal, USGS Crustal Geophysics & Geochemistry Science Center, Denver, CO.

Some energy development in Muddy Creek, WY occurs on marine shales, natural selenium (Se) sources that when disturbed can mobilize Se into streams. We assessed the utility of riparian consumers as indicators of aquatically derived Se. We measured Se concentrations in soil, water, sediment, riparian spiders (*Tetragnatha*), and larval and adult damselflies (*Lestidae* and *Coenagrionidae*) at nine sites. Concentrations of Se in spiders and damselfly larvae exceeded levels safe for fish and wildlife consumption. Se concentrations in spiders increased significantly ($p < 0.05$) with increasing Se in water ($R^2=0.77$) and sediment ($R^2=0.68$). Se concentrations in damselfly larvae decreased with

increasing Se in sediment ($R^2=0.87$) but increased with increasing Se in amphipods ($R^2=0.93$). Adult damselfly Se concentrations showed no trend with Se in larvae, soil, water, or sediment. Stable isotopes ($\delta^{13}\text{C}$, $\delta^{15}\text{N}$) did not discriminate between aquatic and terrestrial sources because terrestrially derived detritus dominated aquatic carbon. Se concentrations in emergent aquatic adults were higher than in terrestrial animals suggesting that exposure to Se was through emergent aquatic prey. We conclude *Tetragratha* is an indicator of terrestrial exposure to aquatically derived Se.

Travis Schmidt, Fort Collins Science Center, 2150 Centre Avenue, Building C, Fort Collins, CO, 80526-8118, Email: tschmidt@usgs.gov.

Natural Salinity Fluctuations in a Snowmelt Dominated Watershed Undergoing Energy Development

Carleton R. Bern, USGS Crustal Geophysics & Geochemistry Science Center, Denver, CO; Melanie L. Clark, USGS Wyoming Water Science Center, Cheyenne, WY; JoAnn M. Holloway; Robert R. McDougal, USGS Crustal Geophysics & Geochemistry Science Center, Denver, CO; Travis S. Schmidt, USGS Fort Collins Science Center, Fort Collins, CO.

The Muddy Creek watershed, located southwest of Rawlins, Wyoming, is part of ongoing regional coal-bed natural gas development. Although produced waters from gas development are currently being reinjected, releases of treated produced waters are being considered. Muddy Creek is relatively unimpacted by irrigation return flows. We examined the chemistry of Muddy Creek to understand natural processes driving salinity in order to establish a baseline for monitoring change in the watershed resulting from potential produced water additions. Discharge, gauged near Baggs, Wyoming, can vary from $0.005 \text{ m}^3 \text{ s}^{-1}$ to $10 \text{ m}^3 \text{ s}^{-1}$ and is dominated by snowmelt in spring. Stream salinity varies inversely with discharge. Soil water and shallow groundwater inputs carry products of sedimentary rock weathering and are the dominant sources of salinity. Salinity from deeper groundwater issuing from springs and historic failed wells is detectable in certain tributaries, but makes negligible contributions to the main stem of Muddy creek. Stream salinity, as measured by electrical conductivity (EC), has almost doubled for a given discharge rate in recent years. In 2006, stream EC averaged 1.0 mS cm^{-1} at a discharge of $0.1 \text{ m}^3 \text{ s}^{-1}$, and in 2011 it averaged 1.9 mS cm^{-1} . The increase in salinity at a given stream discharge rate appears linked to increased shallow groundwater discharge. Shallow groundwater discharge increases are driven by increases in annual precipitation driving groundwater recharge. However, heavy snowpacks in recent years have also increased low salinity flows in the stream during spring snowmelt. As a result, the average EC for total annual stream discharge has remained relatively constant (0.9 mS cm^{-1}). Understanding the nature and magnitude of such fluctuations in baseline natural salinity is crucial to distinguish them from anthropogenic impacts.

Carleton R. Bern, USGS Crustal Geophysics & Geochemistry Science Center, Box 25046, Denver Federal Center, Denver, CO, 80225-0046, Email: cbern@usgs.gov.

Session III B. Concurrent Topic: Assessment and Decision-Aid Tools

Energy and Ecosystems - An Integrated Assessment for Southwestern Wyoming

Zachary Bowen, Patrick Anderson, Timothy Assal, USGS Fort Collins Science Center, Fort Collins, CO; Steven Garman, USGS Rocky Mt. Geographic Science Center, Denver, CO; Steve Germaine and Daniel Manier, USGS Fort Collins Science Center, Fort Collins, CO; Robert McDougal, USGS Crustal Geophysics & Geochemistry Science Center, Denver, CO.

Increased domestic energy production, renewable energy development, and mandates to manage for multiple uses collectively present complex challenges for land and resource managers in southwestern Wyoming. As part of the science and technical support effort for the Wyoming Landscape Conservation Initiative (WLCI) we developed an integrated assessment to inform planning and decision-making in the WLCI area with a focus on informing habitat enhancement and conservation decisions. The assessment is an integrated analysis of WLCI priority resources based on the best available data and information. The integrated assessment includes priority resources (e.g., WLCI partner priority areas, water resources, special management areas), condition indices (e.g., based on distributions of species of concern, WLCI focal habitats), agents of change (e.g., energy and mineral development, roads, invasive plants, climate) and potential for future change associated with development and climate. The integrated assessment summarizes information by watershed into an overall index using a transparent and hierarchical framework. The framework is designed to allow users to decompose summary scores and evaluate individual resources. In addition to supporting landscape-scale conservation planning and evaluation, the integrated assessment is a data and information resource for addressing specific agency management questions. The integrated assessment and the supporting data used to build the assessment are currently available through a web application. A report detailing the work is in preparation.

Zachary Bowen, Fort Collins Science Center, 2150 Centre Avenue, Building C, Fort Collins, CO, 80526-8118, Email: bowenz@usgs.gov.

SUITEWATER: A Watershed-Based Natural Resource Planning and Analysis Tool

Teal B. Wyckoff, Phillip L. Polzer, Wyoming Geographic Information Science Center, University of Wyoming, Laramie, WY; Nephi J. Cole, Natural Resources Conservation Service, Cheyenne, WY; Catherine C. Rosenthal, Wyoming Association of Conservation Districts, Sheridan, WY; Jeffrey D. Hamerlinck, Wyoming Geographic Information Science Center, University of Wyoming, Laramie, WY.

Substantial amounts of financial and human resources are annually expended in the development of natural resource planning to meet conservation objectives in Wyoming. Increasingly, natural resource planning efforts on watershed scales require the compilation of large amounts of spatial and tabular information. In the past the technology and information for completing these plans have been located in a variety of formats and locations, requiring significant inputs of time, effort, and money to bring them into the planning process. In addition, watershed level planning often used data sources and information that differed significantly from plan to plan, thus making compatibility and comparisons over large spatial extents impossible. The SuiteWater

Project is a partnership between the Wyoming Association of Conservation Districts (WACD) and the Wyoming Geographic Information Science Center (WyGISC) aimed at developing a web-based interface to integrate GIS, spatial data, textual information, photography, documents, user generated content, and other information for incorporation into the resource planning process and development of planning documents. To date, the SuiteWater collaboration has produced an informational web portal containing links to water resource planning information, two web-based mapping applications and access to over half a terabyte of spatial data. A public mapping application gives users the ability to explore Wyoming watersheds and quickly obtain key statistics related to a watershed of interest. The WACD member-specific mapping application is a robust and data rich application giving WACD employees access to the tools and data necessary to assist them in the watershed planning process, as well as to meet their day-to-day GIS needs. The development of the web and data resources were guided by an oversight committee made up of WACD, WyGISC, Wyoming Department of Environmental Quality (DEQ) and Wyoming Natural Resource Conservation Service (NRCS).

Teal B. Wyckoff, Wyoming Geographic Information Science Center, University of Wyoming, Department 4008, 1000 East University Ave., Laramie, WY 82071, Email: wyckoff@uwyo.edu.

Building Wisdom to Support Wildlife Decision Making in Wyoming via Web-Based GIS Technology: Overview of the Wyoming Interagency Spatial Database & Online Management System

Jeffrey D. Hamerlinck, Wyoming Geographic Information Science Center, University of Wyoming, Laramie, WY; Kirk A. Nordyke, Wyoming Game and Fish Department, Cheyenne, WY; Philip L. Polzer; Teal B. Wyckoff, Wyoming Geographic Information Science Center, University of Wyoming, Laramie, WY.

The Wyoming Interagency Spatial Database and Online Management (WISDOM) system, Environmental Assessment Support Tool (EAST) is an online “initial assessment” application designed to provide a standard protocol and methodology to better inform land use decision-making related to fish and wildlife species and their habitats in Wyoming. The overall objective of this project is to develop a standard protocol and methodology for creating, storing, maintaining and disseminating environmental and wildlife data for a collection of data providers and making available the most current and accurate spatial representations to a wide network of users including the private, agency, and non-profit sectors. Two key products have been produced to meet this overarching goal: a centralized and highly controlled geospatial database environment and an Internet-based mapping application providing access to these data. This collaboration is between the Wyoming Geographic Information Science Center (WyGISC) and the Wyoming Game and Fish Department (WGFD), with data provision and other formalized partnerships with the Western Governors’ Association, Wyoming Natural Diversity Database, U.S. Fish & Wildlife Service, The Nature Conservancy, Wyoming Department of Environmental Quality, USDA Natural Resources Conservation Service, Wyoming Office of State Lands and Investments, and Wyoming Department of Transportation. From a broader perspective, the WISDOM effort is serving as a pilot project for the Western Governors’ Association, with application to west-wide initiatives for wildlife and environmental management at the interstate and west-wide levels.

Wyoming Integrated Resource Management Application (IRMA): The NRCS Wyoming Cultural and Wildlife Resources Planning Tools

Philip L. Polzer, Wyoming Geographic Information Science Center, University of Wyoming, Laramie, WY; Randy J. Wiggins, Natural Resources Conservation Service, Casper, WY; Teal B. Wyckoff, and Jeffrey D. Hamerlinck, Wyoming Geographic Information Science Center, University of Wyoming, Laramie, WY.

The Wyoming Integrated Resource Management Application (or IRMA), is a joint project of the USDA Natural Resources Conservation Service (NRCS) and the Wyoming Geographic Information Science Center (WyGISC) at the University of Wyoming. IRMA has evolved over the last five years from a desktop to a Web-based application for increased access and ease-of-use by NRCS personnel. Included in the application are two primary modules – the Wildlife Inventory Resource Locator (WIRL) and the Cultural Assessment Resource Locator (CARL). Under the IRMA umbrella these applications provide a single location for NRCS employees to access cultural and wildlife resource information in order to guide implementation of cooperators' conservation practices or planned practices. Based on customizable areas of interest, reports are generated detailing both cultural resource and wildlife resource issues. These outputs assist the NRCS in complying with the Wyoming State Historic and Preservation Office (SHPO) and assist the agency in working with the Wyoming Game and Fish Department (WGFD).

Philip L. Polzer, Wyoming Geographic Information Science Center, University of Wyoming, Department 4008, 1000 East University Ave., Laramie, WY, 82071, Email: ppolzer@uwyo.edu.

Simulating Future Effects of Energy Development on Natural Resources

Steven L. Garman, USGS Rocky Mt. Geographic Science Center, Denver, CO; Daniel Manier, USGS Fort Collins Science Center, Fort Collins, CO.

Understanding potential effects of land uses on ecological resources can help inform management decision making. For instance, density and patterns of energy development may be designed to minimize the effects of surface disturbance on native conditions, such as sagebrush habitat structure and connectivity. Alternatively, certain density and patterns may induce an exponential decline (a tipping point) in native conditions. Identifying land-uses that minimize resource decline and that lead to tipping points (rapid change) helps decision makers determine land uses to promote and to avoid, respectively. We developed a spatially explicit simulation system to evaluate potential effects of land uses on natural resources in SW Wyoming as a means to inform land-use decision making. This system can evaluate a range of possible land uses, and characterize potential effects on natural resources. To date, we've exercised the simulation system over a 65 x 64 km energy field designated as high potential for future development. Baseline information consisted of current vegetation, energy infrastructure, and a cheatgrass habitat suitability map. We simulated the development of oil/gas pads and related infrastructure over a 20-yr period and the potential spread of cheatgrass under different assumptions of future climate. We assessed trends in the aerial amount and

distribution of cheatgrass and native sagebrush relative to the amount of surface disturbance. Results of this initial assessment illustrated tipping points in the spread of cheatgrass and in the decline of native sagebrush when disturbed area reached about 13% of the energy field. Consistency of this tipping point is being evaluated using larger energy fields. Our initial results, however, begin to illustrate land use patterns that may lead to rapid decline in native conditions, and that limit achieving conservation management goals.

Steven L. Garman, USGS Rocky Mt. Geographic Science Center, Box 25046, Denver Federal Center, Denver, CO, 80225-0046, Email: slgarman@usgs.gov.

Session III C. Ecological Assessments & WLCI Focal Ecosystems

It's Not Easy Measuring Green - Or Is It?

Geneva W. Chong, USGS Northern Rocky Mt. Science Center, Bozeman, MT; Heidi Steltzer, Department of Biology and Agriculture, Fort Lewis College, Durango, CO; Rick Shory, Paul Evangelista, Nick Young, and Sara Simonson, Natural Resource Ecology Lab, Colorado State University, Fort Collins, CO.

U.S. Geological Survey researchers, in collaboration with academic and Wyoming Landscape Conservation Initiative (WLCI) partners, are using inexpensive, near-surface reflectance sensors to measure plant greenness, which is a measure of phenology (timing of life history events) and an indicator of productivity. Our goal is to provide resource managers with a tool for measuring and monitoring green-up, maximum greenness and senescence by plant species of interest. Plant green-up is one of the landscape changes a resource manager could monitor to improve decision making. For example, spring green-up can be used as an indicator of forage production, which affects seasonal habitat condition. However, knowing exactly when plants green-up in the spring is not easy. Satellite imagery may be used to calculate an index of greenness, such as the remotely sensed Normalized Difference Vegetation Index (NDVI). But satellite-derived NDVI is limited. Weeks or months may pass without good satellite data, the spatial resolution may be too coarse, and in areas with complex topography or vegetation structure early green-up may not be detected. Ideally, resource managers would have access to more precise green-up data to facilitate decisions regarding elk feedgrounds, fuel production (fire hazard), and nonnative plant species control, for example. In addition, climate change models for the northern Rocky Mountains predict changes in temperature and water availability that in turn will alter vegetation. Changes could include timing of plant life-history events, or phenology, such as green-up, flowering and senescence, and shifts in species composition. Changes in vegetation could make forage for ungulates, sage-grouse, and livestock available earlier in the growing season, but shifts in species composition and phenology may also result in earlier senescence and reduced overall forage production.

Geneva Chong, USGS Northern Rocky Mt. Science Center, National Elk Refuge, P.O. Box 2353, 675 E. Broadway, Jackson, WY, 83001, Email: geneva_chong@usgs.gov.

Sagebrush Ecosystem Conservation and Management: Ecoregional Assessment Tools and Models for the Wyoming Basins

Cameron L. Aldridge, Colorado State University and USGS Fort Collins Science Center, Fort Collins, CO; Steven E. Hanser, USGS Forest and Rangeland Ecosystem Science Center, Boise, ID; Matthias Leu, Department of Biology, College of William and Mary, Williamsburg, VA; Steven T. Knick, USGS Forest and Rangeland Ecosystem Science Center, Boise, ID.

The Wyoming Basins are one of the remaining strongholds of the sagebrush ecosystem. Containing approximately 24 percent of all sagebrush habitats in the United States, this area is an important stronghold for greater sage-grouse and represents a priority ecoregion for conservation planning. However, like most sagebrush habitats, threats to this region are numerous, making conservation actions challenging. The Wyoming Basins provides other significant land uses, including oil, gas, and wind-energy development and accompanying infrastructure necessary for energy transmission. We recently published a new book that adds to current knowledge about the regional status of this sagebrush ecosystem, the distribution of habitats, the threats to the ecosystem, and the influence of threats and habitat conditions on occurrence and abundance of sagebrush associated fauna and flora in the Wyoming Basins. We developed comprehensive methods for data collection and monitoring of wildlife and plant populations, and then integrated field and spatial data into a spatially explicit analytical framework, allowing us to develop models of species occurrence and abundance for the region. This book provides significant new information on distributions, abundances, and habitat relationships for a number of species of conservation concern that depend on sagebrush in the region. The tools and models presented in this book increase our understanding of impacts from land uses and can contribute to the development of comprehensive management and conservation strategies.

Cameron L. Aldridge, Colorado State University and USGS, Fort Collins Science Center, 2150 Centre Avenue, Building C, Fort Collins, CO, 80526-8118, Email: aldridgec@usgs.gov.

Limber Pine (*Pinus Flexilis*) and Other Conifer Presence and Ecotonal Movement on the Landscape of the Ferris Mountains in the Cherry Creek and Pete's Creeks Area from 1681 to 2009.

Robert E. Means, Samuel E. Cox, and Susan Caplan, BLM Wyoming State Office, Cheyenne, WY; William Mack, BLM Kemmerer Field Office, Kemmerer, WY.

Ecotones are transition areas between two ecological communities. Little work has been done in the ecotone between sagebrush/grassland and woodland. The predominate view is that woodlands were historically limited to rocky outcrops and slopes and are moving downhill into the sagebrush/grass communities due to changes in disturbance regimes and management practices. In the study area woodland edges are dominated by limber pine (*Pinus flexilis*), with subalpine fir (*Abies lasiocarpa*) and Douglas fir (*Pseudotsuga menziesii*) in the drainages, while further upslope limber pine mixes with lodgepole pine (*Pinus contorta*) and Engelmann spruce (*Picea engelmanni*). We used dendrochronology and aerial photography to examine woodland movement on the ecotone from 1681 to 2009 and found a more complex picture of vegetative composition and disturbance than is generally acknowledged. Dendrochronology dated the oldest sample to 1681. Two

samples showed fire scars from 1941. Aerial photos from 1949 showed large patches of fresh stand replacement fire with standing dead trees. Within our study area of 23,653 acres, 3,595 acres burned in 1948. Conifer cover (at 95% - closed canopy) was 891 acres in 1949, and 5,359 acres in 2009, an increase of 84%. However, if the 1941 stand replacement burned area is added to the 1949 conifer area, this increase is only 16%. These calculations do not take into account areas of the fire that could not be confidently identified from the aerial photos. We conclude that in this area, the spread of conifers is not a new expansion but rather trees re-occupying areas occupied prior to the 1941 fire. The identification of a 329-year old, lower-slope tree is another indication that limber pine and other conifers were historically present and are not newly-established. When managing ecotones, a long reference timeframe is needed.

Robert E. Means, Bureau of Land Management, Wyoming State Office, 5353 Yellowstone Road, Cheyenne, WY, 82009, Email: rmeans@blm.gov.

Assessing Limber Pine Stand Conditions after Mountain Pine Beetle Outbreaks in the Southern Rocky Mountains

Christy Cleaver, William Jacobi, Forest and Shade Tree Pathology, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins, CO; Kelly Burns, USDA Forest Service, Forest Health Protection, Lakewood Service Center, Lakewood, CO.

Mountain pine beetle and white pine blister rust are causing extensive mortality of limber pines throughout the Southern Rocky Mountains. The combined effects of these organisms and climate change could greatly impact the biodiversity of these fragile and ecologically valuable ecosystems. Information on stand conditions will facilitate management and restoration efforts. The objectives of this study were to: (1) determine the extent and impact of bark beetles and white pine blister rust, and (2) assess composition, structure and health of trees and regeneration. In 2011, we assessed 175 limber pine stands in eight mountain ranges in Northern Colorado and Wyoming. After preliminary data analysis, the highest incidence of white pine blister rust (32-34%) on trees > 1.3 m tall was on Pole Mountain in the Laramie Mountains (WY) and in the Green and Shirley Mountains (WY). The Northern Front Range (CO) and northern and southern halves of the Medicine Bow Mountains (WY) each had < 5% incidence of blister rust. Blister rust was not detected in the Sierra Madre Mountains (WY). The incidence of blister rust on limber pine regeneration < 70 cm tall was 3-4% and regeneration ≥ 70 cm had an incidence of 8-16% in the Green, Pole, and Shirley Mountains. Blister rust was not detected in regeneration in the Medicine Bow or Sierra Madre Mountains. The northern halves of the Medicine Bow and Sierra Madre Mountains had the highest incidence of bark beetle mortality on limber pine at 36 and 30%, respectively, and on dead limber pine at 88% and 91%, respectively. In 2012, we plan to expand our monitoring to new mountain ranges in Wyoming and Montana. Future data analysis will look for relationships to explain successful limber pine regeneration and the impacts of rust and bark beetle mortality on overstory trees.

Christy Cleaver, Department of Bioagricultural Sciences and Pest Management, Colorado State University, Fort Collins CO, 80523-1177, Email: ccleaver@rams.colostate.edu.

Fence-line Contrasts in High-Elevation Wetlands of a Sagebrush Ecosystem: Soil Organic Matter

D. Terrance Booth, Rangeland Scientist (Retired), USDA Agricultural Research Service, High Plains Grasslands Research Station, Cheyenne, WY; Paul J. Meiman, Department of Forest and Rangeland Stewardship, Colorado State University, Fort Collins, CO; **John C. Likins**, (Retired), BLM Lander Field Office, Lander, WY.

The world's wetlands are flow-regulating, water-storing features of hydrologic systems with naturally high soil organic matter (SOM) and a related high water-storage capacity. We questioned whether season-long grazing by free-ranging cattle in the sagebrush ecosystem of the southern upper Sweetwater River drainage, has caused a significant loss of SOM in small, often linear wetlands contributing to perennial feeder streams of the River. In an initial assessment of this question, we measured wetland SOM in the top 25-cm of soil cores taken from inside and outside two fenced exclosures and a >50-year-old private-land pasture (hereafter, exclosure) in three wetlands in the area of interest. The other exclosures were six and nine years old and we collected and analyzed 40 samples from cross-channel transects 10-m above and below exclosure fences. Among all wetland sites (inside and outside), the wetland with the oldest exclosure had the greatest SOM. Across wetlands, SOM inside exclosures averaged 30.7% compared to 23.3% ($P = 0.001$) outside. We recommend (1) further study of riparian grazing effects on SOM, wetland water storage, and streamflow, (2) SOM monitoring in wetlands grazed by livestock, and (3) that the importance of wetland water storage for mitigating greater peak streamflows and lower late flows, be given much greater consideration in land-management.

John Likins, Bureau of Land Management – Lander Field Office, 1335 Main St., Lander, WY, 82520-0589, Email: jlikins@blm.gov.

Sagebrush-steppe Wetlands and Meadows of the Upper Sweetwater River: A Historical Analysis

D. Terrance Booth, (Retired), USDA Agricultural Research Service, High Plains Grasslands Research Station, Cheyenne, WY; John C. Likins, (Retired), BLM Lander Field Office, Lander, WY; Samuel E. Cox, BLM Wyoming State Office, Cheyenne, WY.

Montane wetlands and meadows spread, store, and regulate water flow while providing other valued ecological services. We questioned if a grazing change from herded sheep to season-long free-roaming cattle on the high desert south of the upper Sweetwater River has diminished the region's wetlands. Areal extent is an ecological indicator for wetlands. We used aerial images (0.3- to 1-m ground sample distance (GSD)) collected at approximately 20-year intervals between 1948 and 2005 to test for decreased wetland area. We used a 2008 aerial survey (systematic, intermittent, nested 1-, 8-, and 18-mm GSD) along 150 km of streams to look for in-stream erosion features. The historical images provided no evidence of a wetland-area trend; however, we show that 1-m GSD imagery is inadequate for detecting regional channel erosion. Eleven named streams were surveyed in 2008 and all but three had headcuts. The three streams without headcuts were either <1,000 m long, or had been remediated. Approximately 90% of scenes showed distinct herbivore trailing. We conclude that active headcutting and channel scouring evident in 2008 images indicates past and on-going loss of wetland/meadow area and water-storage capacity. Given the 2008 evidence of headcut erosion and high herbivore

concentration on the region's riparian systems, we recommend grazing-management changes, headcut remediation, and monitoring the rate of soil organic matter replacement in area meadows and wetlands. We recommend riparian monitoring include systematic, intermittent sampling by acquisition of nested imagery on the order of 1, 8, and 18-mm GSD.

Terrance Booth, 8408 Hildreth Road, Cheyenne, WY, 82009, Email: terry.booth@ars.usda.gov.

Riparian Forests in Dry Landscapes

Gregor T. Auble, USGS Fort Collins Science Center, Fort Collins, CO.

Riparian forests provide rare and valuable features in landscapes that are generally too dry for trees. Consequently they are often a focal point for the consideration of environmental impacts of development and management activities as well as a target of restoration effort. In some senses these are simple ecosystems – a small number of important woody species, strong and distinctive spatial and temporal patterns, and dominance of single physical factor (streamflow-determined moisture) in determining structure and behavior. In practical application, however, that simplicity is complicated by the mediating role of specific geomorphic setting, the importance of infrequent events, the persistent signature of long-past events, important disturbance-dependent species, effects of herbivory, changes in the regional species pool, and a tendency for these systems to be in a state of transition frequently far from any single, long-term steady state. Emphasizing examples from applied studies by riparian ecologists at the Fort Collins Science Center of the US Geological Survey, I review the life history characteristics and autecology of selected plains riparian trees, the principal factors determining the structure and dynamics of these plains riparian forests, some of the distinctive responses to human alteration that have been observed, and some of the conceptual and analytical tools to inform impact assessment and restoration.

Gregor T. Auble, USGS Fort Collins Science Center, 2150 Centre Avenue, Building C, Fort Collins, CO, 80526-8118, Email: auble@usgs.gov.

Session III D. Monitoring Methods, Approaches, and Tools

Synthetic Satellite Imagery- A New Tool for Long-term and Effectiveness Monitoring of Habitat Treatments

Edward Olexa, USGS Northern Rocky Mountain Science Center, Bozeman, MT; Rick Lawrence, Spatial Sciences Center, Montana State University, Bozeman, MT.

Natural resource managers require objective detailed information about dynamic vegetation characteristics when evaluating conditions and trends associated with habitat treatments. Data collected by Earth observing satellites can be used to measure biophysical and phenological characteristics of vegetation at multiple spatiotemporal scales and extents. The Landsat satellite series is the most widely used platform for investigating changes in land cover and land use; however, a 16-day return interval often limits its ability to monitor dynamic conditions. Other sensors, such as the Moderate Resolution Imaging Spectroradiometer (MODIS), have a revisit cycle of 1-2 days, but

lack the spatial resolution often needed to evaluate habitat responses to treatments. The Spatial and Temporal Adaptive Reflectance Fusion Model (STARFM) seeks to alleviate these limitations and could assist with monitoring seasonal and interannual changes in plant phenology and biomass across broad spatial extents at fine spatiotemporal scales. STARFM uses date-paired MODIS/Landsat image sets to create synthetic Landsat images when MODIS data are available but Landsat data are lacking. STARFM has successfully predicted surface reflectance values across homogeneous landscapes, but has not been applied to the heterogeneous shrub-steppe dominated habitats of southwest Wyoming. We evaluated STARFM's ability to predict surface reflectance and Normalized Difference Vegetation Index (NDVI) values for several land cover/ land use types common in the WLCI area. Reflectance and NDVI values were successfully predicted across the study area. Estimates correlated well with measured values and were reasonably accurate and unbiased. The strength of these relationships decreased as the lag between input and prediction dates increased. Performance also varied among land cover/ land use types. Synthetic reflectance and NDVI data should be useful to land managers seeking to monitor intra- and interannual changes in plant biomass or phenology associated with vegetation treatments.

Edward Olexa, USGS Northern Rocky Mountain Science Center, 2327 University Way Suite 2, Bozeman, MT, 59715, Email: eolexa@usgs.gov.

Understanding Sagebrush Component Change across the Wyoming Landscape Conservation Initiative Area with Remote Sensing, 2006-2010

Collin Homer, and Debbie Meyer (contractor), USGS Earth Resources Observation and Science Center, Sioux Falls, SD; Cameron Aldridge, Colorado State University and USGS Fort Collins Science Center, Fort Collins, CO.

Sagebrush ecosystems occupy a large portion of the western United States and provide unique ecosystem services. However, these systems occur in arid and semiarid areas and are vulnerable to external disturbances such as fire, climate change, and human disturbance. Good understanding of the spatial distribution and change patterns of these ecosystems is vital for land and wildlife management and increased understanding of landscape scale processes. The implementation of new remote sensing protocols allows the monitoring of sagebrush component change over the entire Wyoming Landscape Conservation Initiative (WLCI) region. Baseline 2006 WLCI predictions of seven cover components (bare ground, herbaceous, litter, shrub, sagebrush, big sagebrush, and Wyoming sagebrush) are estimated using field measurements, QuickBird 2.4m imagery, and Landsat 30m imagery with regression tree models. To analyze the amount of change in the WLCI region between 2006 and 2010, three dates of Landsat imagery (spring, summer, and fall) from each year are compared for change detection analysis. New area predictions from 2010 are compared to the 2006 base predictions to calculate the overall change amounts. Results indicate bare ground decreased by a total area of almost 53 km² from 2006, herbaceous cover decreased by 63 km², big sagebrush decreased by approximately 11 km², and Wyoming big sagebrush decreased by approximately 19 km². On the other hand, litter increased by almost 64 km², shrub (which includes many species in addition to sagebrush) increased by approximately 52 km², and all other species of sagebrush increased by approximately 9 km². Changes were further stratified into three potential change drivers including fire, human induced disturbance, and other change (typically climate variation). Approximately 6% of the change was due to fire, 4% due to human disturbance, and 90% due to other effects such as climate. The precipitation trends

of the last four years likely resulted in most of the change that occurred in the other category.

Collin Homer, USGS Earth Resources Observation and Science Center, 47914 252nd St., Sioux Falls, SD, 57198, Email: homer@usgs.gov.

Assessment and Monitoring of Semi-Arid Woodlands in the Little Mountain Ecosystem

Timothy Assal, Patrick Anderson, and Alexandra Urza, USGS Fort Collins Science Center, Fort Collins, CO.

The effectiveness monitoring task of the WLCI is intended to help guide the design and development of habitat treatments to meet WLCI landscape conservation objectives. The development of baseline ecological data is critical to the success of this task. This paper describes the assessment of a WLCI focal habitat (aspen) in a WLCI Local Project Team Development Area (Little Mountain Ecosystem). A fine-scale map of aspen and conifer distribution in this area is needed because existing regional data sets were not designed to support decisions at localized scales. We employed Classification and Regression Tree (CART) analysis to map aspen and conifer communities using SPOT satellite imagery (10 meter resolution). We utilized multiple scenes that included summer imagery (aspen leaf-on) and autumn imagery (aspen leaf-off) to improve delineation of deciduous aspen trees from coniferous species such as subalpine fir and Douglas-fir. The information from this task can be used to aid management and effectiveness monitoring efforts and the methodology can be applied to other areas of the WLCI. Furthermore, this area was affected by a severe, multiyear drought in the early part of the decade. Aspen and conifer woodlands exist at the xeric fringes of their range in this important ecotone, but little is known about the impacts of drought on these communities. Resource managers are faced with increasing levels of uncertainty about future landscapes and recent disturbances afford the opportunity to study the impacts of such events that are predicted to increase in frequency over the next century. Remote sensing methodologies provide a cost effective way to monitor change in the woodlands of this area over the recent past. Furthermore, this effort provides spatially explicit information on both management treatments and natural disturbances such as wildfire, severe drought, and insect related tree mortality.

Timothy Assal, Fort Collins Science Center, 2150 Centre Avenue, Building C, Fort Collins, CO, 80526-8118, Email: assalt@usgs.gov.

Proper Functioning Condition (PFC) and Multiple Indicator Monitoring (MIM) Overview

Dennis Doncaster, BLM Rock Springs Field Office, Rock Springs, WY.

A general overview of the qualitative Proper Functioning Condition (PFC) and quantitative Multiple Indicator Monitoring (MIM) riparian monitoring methods, and how they work together.

Dennis Doncaster, Bureau of Land Management, Rock Springs Field Office, 280 Hwy., 191 N., Rock Springs, WY, 82901-3448, Email: ddoncast@blm.gov.

The WLCI Interagency Monitoring Team: Efforts and Accomplishments

Daniel Manier, Cherokee Services Group and USGS Fort Collins Science Center, Fort Collins, CO; **Steve Garman**, USGS Rocky Mountain Geographic Science Center, Denver, CO; **Marie Dematatis**, Chicago Botanical Intern and BLM Rock Springs Field Office, Rock Springs, WY.

The WLCI Inter-Agency Monitoring Team (MT) was formed to gather and synthesize information on monitoring activities throughout the WLCI. A goal of the MT is to compile detailed information on monitoring efforts in a centrally-located accessible format for use as a reference tool to help inform monitoring by local project teams and others. Additionally, a goal is to develop integrated approaches for coordinated monitoring across agencies and the WLCI landscape. Team members from multiple agencies and affiliations have identified previous and ongoing monitoring efforts of value for assessing the status and long-term trends in resource conditions across the region. Because of the potentially large number of contributions (a preliminary compilation of records documents more than 100 projects and/or datasets from 8 different agencies), and the need for timely results, we have prioritized current efforts to focus on data and methods relating to important wildlife, Federally listed or pending T&E species, distribution and condition of terrestrial, wetland and aquatic habitats, vegetation and ecosystem structure and function, hydrologic function, soil conditions, and effects of restoration and other management actions. Acquired information is recorded in a database designed to facilitate information assessment and sharing, as demonstrated by a case study of rangeland monitoring within the Rock Springs Field Office. Initial discussions with rangeland conservation specialists consisted of information acquisition and record documentation. A comparison of existing methods identified opportunities to develop consistency and coordination. A consensus was reached resulting in designated protocols and common methods for future implementation across the Field Office area. These protocols identify a means to collect, analyze and store data in a manner that is consistent over a large spatial and temporal extent. In this presentation we provide an overview of the MT effort, and recent assessments of acquired information related to rangeland monitoring in SW Wyoming.

Daniel Manier, Cherokee Services Group, LLC, Fort Collins Science Center, 2150 Centre Avenue, Building C, Fort Collins, CO, 80526-8118, Email: manierd@usgs.gov; Marie Dematatis, Bureau of Land Management- Rock Springs Field Office, 280 Hwy., 191 N., Rock Springs, WY, 82901-3448, Email: MDematatis@blm.gov.

Poster Presentations

Evaluating Natural Gas Development Impacts on Stream Ecosystems in an Upper Colorado River Watershed

JoAnn M. Holloway, Carleton Bern, USGS Crustal Geophysics & Geochemistry Science Center, Denver, CO; Travis S. Schmidt, USGS Fort Collins Science Center, Fort Collins, CO; **Robert R. McDougal**, USGS Crustal Geophysics & Geochemistry Science Center, Denver, CO; Melanie L. Clark, USGS Wyoming Water Science Center, Cheyenne, WY; Craig A. Stricker, USGS Fort Collins Science Center, Fort Collins, CO; Ruth E. Wolf, USGS Crustal Geophysics & Geochemistry Science Center, Denver, CO.

Oil and gas development in the western United States is increasingly placing at odds the management of two critical natural resources: fossil fuels and water. Muddy Creek, part of the Upper Colorado River watershed, is a semi-arid catchment in a sagebrush steppe ecosystem. Muddy Creek flows throughout the year and includes both perennial and ephemeral tributaries. Primary land use includes livestock grazing, oil and gas development, and recreational activities. A multi-discipline study has been initiated to determine potential impacts of the projected increase of coal bed natural gas development. Hundreds of permits for drilling co-produced waters have been issued, but low energy prices have slowed development. A watershed assessment was conducted in 2010 to determine areas within the watershed that are more susceptible to mobilization of trace elements that occur in soils forming on marine shales. Soil, stream sediment, and water samples were collected and analyzed for major elements and a suite of trace elements, with arsenic and selenium identified as potential elements of concern. A study of benthic and riparian invertebrates is being conducted to evaluate the uptake of these elements into the food web at targeted locations in the Muddy Creek watershed. Continued work will address sources of salinity to Muddy Creek, and ultimately to the Upper Colorado River. Impacts from energy development can include mobilization of naturally occurring sulfate salts through soil disturbance. Formation waters currently discharged to the surface from two failed wells within the watershed will be evaluated for their contribution to salinity, as well as dissolved organic carbon, nitrogen species, and trace elements, to the Upper Colorado River. Upon completion, this study will provide a baseline that can assist in land-use management decisions as oil and gas extraction expands in the Upper Colorado River watershed.

Robert McDougal, USGS Crustal Geophysics & Geochemistry Science Center, Box 25046, Denver Federal Center, Denver, CO, 80225-0046, Email: rmcdouga@usgs.gov.

Survey of Low-Elevation Aspen Woodlands in the Green River Basin

George Jones, Wyoming Natural Diversity Database, University of Wyoming, Laramie, WY.

In 2004, the Wyoming Natural Diversity Database and BLM initiated a cooperative project to study low-elevation aspen stands scattered throughout the Green River Basin. We used 3 digital layers to select potential sampling points in areas shown as aspen woodland, and in 2008, visited 52 points. Aspen grew at only 16 points (31%). Most incorrectly classified points were in mountain big sagebrush stands, with a few in limber pine or greasewood stands. In 18 aspen stands, we sampled in 24 distinct patches of trees, using a belt transect to collect information about tree size and density, canopy and trunk health, numbers and sizes of fallen logs, and common undergrowth species. We estimated size of the stand, and recorded slope steepness, aspect, position on the landscape, and substrate. Aspen stands occur predominantly on slopes facing north-northwest to southeast, generally on upper slopes, and on residual parent materials. Stands are small (half of our stands < 1 ha), generally contain at least 2 distinct patches of trees, and most consist solely of aspen. Densities and sizes of trees vary widely, but small trees (<4.5 feet tall) are the most widespread and densest. Larger trees are less common and grow in much lower densities. Fallen logs suggest that this has long been the case. Small trees are generally vigorous, but larger trees less so. Browsing upon all size classes appears to be light. Two indicators suggest that regeneration of aspens is spotty: aspens < 1 in. dbh reached threshold density of 500 stems / acre in 11 of 24

patches, and aspens > 2 m tall and < 10 cm dbh grew in 15 patches. In 2012, we will sample more stands, modifying our methods to better estimate stand size and to determine whether stands have been expanding or contracting.

George Jones, Associate Director Wyoming Natural Diversity Database, University of Wyoming, Department 3381, 1000 East University Avenue, Laramie, WY, 82071, Email: gpjones@uwyo.edu.

Extraction of Oil and Gas Pads from NAIP Imagery in Southwest Wyoming

Jamie L. McBeth, USGS Rocky Mt. Geographic Science Center, Bozeman, MT; Steven L. Garman, USGS Rocky Mt. Geographic Science Center, Denver, CO.

Surface disturbance of oil and gas pads and related infrastructure is a critical baseline data layer for land-use assessments in the Wyoming Landscape Conservation Initiative (WLCI). Object-oriented software programs such as Trimble's eCognition® and Overwatch's Feature Analyst® have been employed to extract pad information from satellite imagery of varying resolutions. These approaches required considerable time investments given the need to adjust rule sets and extraction parameters to produce moderately acceptable results for this semi-arid environment, and the level of clean-up required to correct the amount of commission and omission errors. We developed an approach to extract surface disturbance of pads from 1-m, 4-band NAIP imagery acquired in 2009 that provides reasonable representation of surface disturbance of pads while minimizing cleanup requirements. This procedure employs a hierarchy of Classification and Regression Tree models that uses spectral values to identify pad areas, and additional rule-sets related to shape and size. Models and rule sets were developed using digitized pads and other infrastructure from a high-density energy field in southwest Wyoming. Our procedures result in polygons that approximate surface disturbance due to pads, and have reduced 'clutter' compared to previous methods. Manual clean-up is still required to correct commission and omission errors and to enhance pad boundaries; however, clean-up requirements are generally less extensive than required with previous methods. We have used our approach to extract pads from the 2,213 NAIP images that cover the WLCI and have completed manual cleanup of 931 images, which represent 57 percent of the WLCI's 19 million acres.

Jamie McBeth, USGS Rocky Mt. Geographic Science Center, 2327 University Way, Suite 2, Bozeman, MT, 59715, Email: jlmcbeth@usgs.gov.

U.S. Geological Survey Water-Resources Data—NWISWeb: A Data Tool for the WLCI

Kirk Miller, USGS Wyoming Water Science Center, Cheyenne, WY.

The U.S. Geological Survey provides water-resources information through the online National Water Information System web (NWISWeb). Information is readily accessible by managers and the public for assessing water-resources in the context of changes in land use, land cover, and climate. Current and historical information is available for over 1.5 million sites and includes streamflow, groundwater, and water-quality data, statistics, and metadata. Tools allow for selecting sites by various criteria including State, site number, and site type. Information can be displayed in tables, graphs, and maps and

output to computer files. NWISWeb is available online at permanent URL <http://waterdata.usgs.gov/nwis>.

Kirk Miller, USGS Wyoming Water Science Center, 521 Progress Circle, Ste 6, Cheyenne, WY, 82007, Email: kmiller@usgs.gov.

Wyoming Groundwater-Quality Monitoring Network

Gregory K. Boughton, USGS Wyoming Water Science Center, Cheyenne, WY.

The Wyoming Groundwater-Quality Monitoring Network (WGQMN) is a cooperative effort between the U.S. Geological Survey and the Wyoming Department of Environmental Quality implemented in 2009 to evaluate the State's groundwater. The WGQMN samples wells to establish baseline groundwater quality in priority areas where groundwater has been identified as an important source of public or private water supplies, is susceptible to contamination, and is overlain by one or multiple land-use activities that could negatively impact groundwater resources. The WGQMN project area consists of 33 priority areas identified by the Wyoming Department of Environmental Quality's Aquifer Prioritization for Ambient Ground Water Monitoring Project in the 7 principal river basins of the state. Groundwater samples are collected from existing shallow wells (500 feet or less). Wells are stratified by depth and aquifer type. Upon further evaluation of data, a subset of wells are selected to include in the WGQMN. All groundwater samples are analyzed for a number of standard analytes (major ions, trace elements, nutrients, volatile organic compounds, total dissolved solids, dissolved organic carbon, H-2/H-1 and O-18/O-16 isotope ratios, bacteria, and alkalinity) and selected samples are also analyzed for supplemental analytes (waste water compounds, tritium, gross-alpha/gross-beta radioactivity, radon-222, diesel range organics, gasoline range organics, dissolved hydrocarbon gases, and biological activity reaction tests). The Wyoming Landscape Conservation Initiative (WLCI) has funded the collection and analysis of additional groundwater samples from deeper aquifers than the statewide program (500 – 1,200 feet). WGQMN activities for the WLCI began with the sampling of 4 wells in the Greater Green River Basin in December 2009. Groundwater samples were collected from another 5 wells in the Greater Green River Basin in September 2011. Groundwater sampling is expected to continue in 2012 at 4-5 additional wells within the WLCI boundary.

Gregory Boughton, USGS Wyoming Water Science Center, 521 Progress Circle, Ste 6, Cheyenne, WY, 82007, Email: gkbought@usgs.gov.

Bankfull-Channel Geometry and Discharge Curves for the Rocky Mountains Hydrologic Region in Wyoming

Katharine Foster, USGS Wyoming Water Science Center, Cheyenne, WY.

The U.S. Geological Survey (USGS), Wyoming Water Science Center in cooperation with the Watershed Program of the Wyoming Department of Environmental Quality, Wyoming Department of Game and Fish, the U.S. Department of Agriculture Forest Service, Region 2, and partners in the Wyoming Landscape Conservation Initiative, conducted a study to collect bankfull-channel geometry and bankfull discharge data at streamgages within the Rocky Mountains Hydrologic Region in Wyoming because of the

need for more information about the relation of channel geometry and stream discharge to watershed area. Regional curves relate bankfull-channel geometry and bankfull discharge to drainage area in regions with similar runoff characteristics and are used to estimate the bankfull discharge and bankfull-channel geometry when the drainage area of a stream is known. One-variable, ordinary least-squares regressions relating bankfull discharge, cross-sectional area, bankfull width, and bankfull mean depth to drainage area were developed from data collected at 39 streamgages in or near Wyoming. Watersheds draining to these streamgages are within the Rocky Mountains Hydrologic Region of Wyoming and neighboring states. Two sets of regional curves were developed; one for streamgages representing the range of mean annual precipitation and one for streamgages with greater than 25 inches mean annual precipitation. Drainage area explains most of the variability in cross-sectional area for all streamgages and for streamgages with greater than 25 inches mean annual precipitation ($R^2 = 0.83$, and 0.91 respectively). For all streamgages and streamgages with greater than 25 inches mean annual precipitation, drainage area explains less of the variability in bankfull discharge ($R^2 = 0.74$ and 0.87 , respectively), bankfull width ($R^2 = 0.81$ and 0.83 , respectively) and bankfull mean depth ($R^2 = 0.44$ and 0.64 , respectively). Some streamgages exhibited influence, leverage, or both on all regional curves developed for the Rocky Mountains Hydrologic Region.

Katharine Foster, USGS Wyoming Water Science Center, 521 Progress Circle, Ste 6, Cheyenne, WY, 82007, Email: kafoster@usgs.gov.

Session IV: Addressing Change through Management and Conservation Actions

Many of the WLCI partners are addressing change through management and conservation actions. Some of these actions include the treatment of invasive species, the collection of native seeds for immediate restoration and commercial development for large-scale reclamation and restoration activities, aquatic and terrestrial habitat treatments, wildlife friendly fence conversions and agriculture and grazing management practices that benefit wildlife. This session will focus on research, monitoring, and other assessments associated with some of these management and conservation actions. Lessons learned and the effectiveness of these actions will be presented to improve restoration, reclamation, and habitat treatments and to improve and better implement Adaptive Management practices.

Oral Presentations

Session IV A. Distribution, Evaluation and Treatment of Invasive Plants

The Distribution of Invasive Plants Measured and Modeled Across the WLCI Area.

Daniel Manier, Spencer Schell, USGS Fort Collins Science Center, Fort Collins, CO; Cameron Aldridge, USGS Fort Collins Science Center and Colorado State University, Fort Collins, CO.

Sagebrush rangelands provide important ecosystem services including quality wildlife habitats and domestic forage production; these systems are expected to continue to provide these services into the future, despite expectation of increasing land-use pressures and climate-driven changes. The dominating influence of noxious, invasive plants, including cheatgrass (*Bromus tectorum*), desert alyssum (*Alyssum desertorum*), and

halogeton (*Halogeton glomeratus*) represents a critical threat to quality wildlife habitats and livestock forage. As the landscape changes, opportunities for weeds on public and private, managed, and native systems continue to be created. Our research has identified several important predictors of weed distributions, including geology, surface hydrology and land-use patterns. This understanding can help inform current planning and management decisions, and can be used to structure future research. In addition, we used statistical relationships between environmental variables and weed occurrence to map the potential distribution of several species. We will present a summary of the development process, mapped distribution models for several species of concern, and a discussion of the “best” predictors of weed distributions as demonstrated by our data. Based on understanding of potential distributions and environmental correlations, these projections can inform strategic planning for weed control at regional and local scales. Importantly, these approaches can be used for native and invasive species, different sized regions, and compiled data, with new observations easily incorporated for model revision, offering a potentially important tool for increasing the benefits of rapid assessments and population surveys.

Daniel Manier, Cherokee Services Group, LLC, Fort Collins Science Center, 2150 Centre Avenue, Building C, Fort Collins, CO, 80526-8118, Email: manierd@usgs.gov.

Noxious weeds in Wyoming – Wyoming Weed and Pest Districts.

Kimberly Johnson, Fremont County Weed and Pest, Riverton, WY.

Fremont County Weed and Pest has been one of the leaders in data gathering and using the information to structure weed treatment priorities. We have had a surveying crew for seven years whose primary focus is to survey areas where spray crews do not go. This is the main part of our Early Detection program. For the past three years we have had a Rapid Response crew. Using our gathered data we set parameters to determine which infestations will be considered high priority treatment. The Rapid response crew is responsible for the bulk of these treatments. This is considered the Early Detection and Rapid Response (EDRR) part of our management plan, equal in importance to other established programs. Each county in the state of Wyoming has a Weed and Pest District funded by a one mill property tax. Some counties with leafy spurge or other special management weed targets can take up to 2 mills. So funding, and therefore programs, varies from county to county. Recording weed locations is something that every county now does. Similar to the fact that each county has their own weed management program; each county has their own methods and philosophy about recording infestations. Every county would like to have as much information about the location of weed infestations as possible. So in addition to their own programs, they are also looking to gather information from outside sources. “The big picture” on weed distribution is now being utilized by Districts and becoming a vital part of their weed management strategies.

Kimberly Johnson, Fremont County Weed and Pest, 1446 Cowboy Lane Riverton, WY 82501, Email: kim@wyoming.com.

Strategic Management of Cheatgrass in Wyoming.

Brian A. Mealor, University of Wyoming, Laramie, WY.

Annual *Bromus* species are perhaps the most ubiquitous and problematic weedy species of western rangelands. Some land managers and scientists have historically minimized potential impacts of annual bromes in our region, but brome populations are exhibiting an increasing trend in Wyoming and Colorado. The rate of expansion is predicted to increase relative to climate change models. Current perceptions of downy brome impacts on forage availability and efficacy of control methods vary widely among natural resource professionals and land managers throughout the state. Although its prevalence is increasing, the current distribution may present opportunities to prevent crossing an ecological threshold in many areas because an increase in fire frequency has not yet occurred. In heavily-infested areas, chemical control alone may be insufficient to convert annual-dominated rangelands to perennial-dominated grasslands with higher forage value. Challenges to developing a successful management program for such a widespread invasive as downy brome may be exacerbated where multiple ecological regions converge and ecological responses to control tactics differ across the management landscape. An additional challenge in both the western Great Plains and Wyoming Basin is the widespread surface disturbance related to the resource extraction industry. Such challenges may only be successfully addressed by implementing an integrated strategy including proactive prioritization of investment into protecting areas with high-quality habitat from future impacts, aggressively managing bromes in areas with high recovery potential and approaching thresholds, and managing grazing to favor desirable perennial species. Regional cooperative groups involving ranchers, agency personnel, researchers, and others may lead to productive landscape-scale programs.

Brian A. Mealor. Dept. of Plant Sciences, University of Wyoming 3354 1000 E. Univ. Avenue, Laramie, WY. 82071. Email: bamealor@uwyo.edu,

Controlling *Bromus tectorum* aka Cheatgrass using Integrated Management in Oil and Gas Development in South West Wyoming.

Deej Brown, BLM Kemmerer Field Office, Kemmerer, WY.

The development of oil and gas in Southwest Wyoming has help open doors for the invasion of non-native plants into the ecosystem. The high desert sagebrush communities found in Southwest Wyoming have a variety of sensitive soils that when disturbed are targeted by undesirable plants such as Cheatgrass (*Bromus tectorum*). In 2008 within the Jonah oil and gas field a half mile of reclaimed pipeline was identified to have great densities of cheatgrass ranging from 61% cover to > 68% cover. This resulted in a treatment plan that included three treatment plots that were +/- half acre in size and a written integrated management plan using both chemicals and mechanical/ cultural methods were developed that has proven to have reduced the infestation to a post treatment of < 1% cover from > 63% pretreatment. The initial treatment of 2 oz. per acre Imazipic and hand pulling of the cheatgrass has resulted in control of the cheatgrass for the past four growing seasons, with no damage to the native plants that has been noted. These first plots have made way for research to approve another chemical Rimsulfuron, for use on cheatgrass by the BLM in the near future. To date over 300 acres of cheatgrass infested upland have been treated to result in the reduction of the infestations of > 37% in

the first year. Oil and gas companies are utilizing integrated management plans for cheatgrass based these results in several fields within the Pinedale area, in addition using this same approach to control cheatgrass in many areas within the Kemmerer field office. In Pinedale a Cheatgrass task group has been formed, and is moving forward on treatments in coordination with the local sage grouse working group, Wyoming Game and Fish and the Sublette County Weed and Pest District, BLM and WLCI. Brown, DeeJ. BLM Kemmerer Field Office. 312 HWY 189 North. Kemmerer, WY. 83101. Email: debrown@blm.gov.

Session IV B. Concurrent Topic: Conservation Planning, Partnerships, and Ecosystem Services

Assessing Socioeconomic Planning Needs (ASPN) Decision-Support Tool.

Jessica M. Montag, Leslie Richardson, Lynne Koontz, Natalie Sexton, USGS Fort Collins Science Center, Fort Collins, CO.

Lands and resources managed by federal agencies provide many goods and services that contribute to the social and economic well-being of local communities and society as a whole. These include such benefits as recreational opportunities, commercial uses, ecosystem services, and subsistence. Management actions on these lands can affect various private and public stakeholders who often have diverse values and preferences about the use and management of public resources. Therefore, these social and economic impacts of planning and management need to be adequately and systematically addressed, particularly in controversial situations where diverse stakeholders are highly engaged and may contest management decisions. USGS scientists have worked with the BLM, NPS, and USFS to develop a web-based decision tool for Assessing Socioeconomic Planning Needs (ASPN) which enables natural resource managers and planners to develop custom socioeconomic assessment plans tailored to their individual land units and specific planning needs. ASPN allows planners and managers to establish the broad social and economic themes they may want to address, identify sub-issues to assess under those broad themes; and determine the intensity of the issues. ASPN then suggests analysis methods for addressing the identified issues using various inputs including time and budget needs. This tool will improve the planning process by: 1) systematically covering the breadth of issues facing land and resource management agencies; 2) identifying and prioritizing the planning issues that will require a social and/or economic analysis in the management plan; 3) providing a range of recommended social and economic methods which could be used to address the identified planning issues 4) realistically accounting for budget and time constraints; 5) including consideration of appropriate regulations regarding environmental policy; and 6) providing justification and documentation of the chosen analysis and tools.

Jessica M. Montag, USGS Fort Collins Science Center, 2150 Centre Ave., Bldg. C, Fort Collins, CO 80526-8118, Email: montagj@usgs.gov.

Collaborative Mapping and Social Learning: Interactive GIS for Natural Resource Management.

Jessica M. Montag, USGS Fort Collins Science Center, Fort Collins, CO; Patrick Reed, USFS, National Forest System, Anchorage, AK.

Collaborative public involvement in the preparation of National Forest land management plans is a regulatory mandate (36 CFR 219). Typical “scoping” activities in that public involvement have not been GIS-based, instead comments received are assumed to apply to the entire forest or to a part of the forest through a verbal description. In addition, there has been little if any opportunity for individuals to see or react to the comments of others until they are compiled at the end of the commenting period. Thus, comments are in effect geographically imprecise as well as isolated from collaborative learning opportunities. The US Forest Service, in cooperation with the US Geological Survey, is presently developing a “collaborative mapping” web-based tool to improve both of the above limitations. A typical web-site user will be able to attach written comments to either a single point, line, or a polygon. In addition, they may attach a photograph or link to a document. Another user has the opportunity to add to that comment and create a conversation—visible to all and open to further commenting. National forest staff will also have the ability to enter into those “conversations.” The outcome is that the exchange of information, and learning, can occur much earlier in the planning process and with greater transparency. There is no limit to the number of public comments, or responses to those comments, that can be entered. National forest staff will be able to query and sort comments on key words, text strings, and dates. Thus, they are quickly able to also see where certain types of comments (if any) seem to be occurring. Designed primarily for enhancing collaboration with the public the tool may serve effectively as an “internal” collaboration tool for interdisciplinary teams (IDTs) or project teams for better communication among team members.

Jessica M. Montag, USGS Fort Collins Science Center, 2150 Centre Ave., Bldg. C, Fort Collins, CO 80526-8118. Email: montagj@usgs.gov.

Quantifying the Benefits of the Core Area Policy and Conservation Easements to Sage-Grouse in Wyoming.

Holly Copeland and Amy Pocewicz, The Nature Conservancy, Lander, WY; David E. Naugle, University of Montana, Missoula, MT; Tim Griffiths, NRCS, Bozeman, MT; Doug Keinath, Wyoming Natural Diversity Database, University of Wyoming, Laramie, WY; Jeffrey Evans, The Nature Conservancy, Laramie, WY; Jody Daline, The Nature Conservancy, Lander, WY.

New energy and residential development is transforming landscapes of the Intermountain West. Of particular concern is the convergence of development and sage-grouse populations in Wyoming. Bold actions have been taken by federal agencies, states and land trusts to conserve sage-grouse through conservation easements and policy changes that limit development. We developed build-out scenarios to simulate future energy and residential development to measure the efficacy of conservation actions at protecting sage-grouse populations. Our analysis addressed the following questions: (1) How much sage-grouse population loss is averted by conservation easements and/or a sage-grouse core area policy? and (2) What is the return-on-investment for sage-grouse populations

associated with these conservation actions? We found that Wyoming sage-grouse populations can be expected to decline by 11-18% even with the core area policy in place. Conservation easements have the potential to further abate this loss, with each \$100 million of easements reducing expected declines by 3% if targeted in core areas, but up to 10% if targeted to the largest populations with the greatest threats. Our results provide unbiased estimates of the impacts of future fragmentation on sage-grouse and the potential contribution of the Wyoming's core area policy and private conservation easements at varying levels of funding. These estimates can guide the quantity and placement of future conservation work, so that federal and state agencies can work together with land trusts to support enough conservation in the right places to maintain a large and functioning sage-grouse population.

Holly Copeland. The Nature Conservancy. 258 Main Street, Lander, WY. 82520. Email: hcopeland@tnc.org

Development of a Market for Ecosystem Services in the Upper Green River Basin.

Roger H. Coupal, Dept. of Agricultural & Applied Economics, University of Wyoming, Laramie, WY; Kristiana Hansen, Dept. of Agricultural & Applied Economics, University of Wyoming, Laramie, WY; Amy Pocewicz, The Nature Conservancy Lander, WY; **Melanie Purcell**, Sublette County Conservation District, Pinedale, WY.

Payments for Ecosystem Services (PES) is an innovative way to provide financial incentives or compensation to private landholders for engaging in environmentally or socially beneficial activities that might not otherwise be undertaken or continued. Our team (comprised of scientists and rangeland specialists at the University of Wyoming, The Nature Conservancy, and Sublette County Conservation District) is scoping the potential for a PES program in the Green River Basin. The ecosystem services considered are maintenance or improvement of downstream water resources and maintenance or improvement of wildlife habitat and riparian condition. Examples of practices under consideration include altered grazing patterns and choice of irrigation practices and timing. Some practices provide multiple ecosystem services that could then be bundled for multiple buyers. The basin is one of the key headwaters of the Colorado River and home to one of the nation's largest natural gas fields. A PES mechanism appeals to members of the community, who are looking for ways to maintain traditional land uses in spite of development pressures within the basin. This PES project will adopt the techniques of verification and accounting tested in other PES programs but involve the community in determining watershed and habitat improvement approaches that best fit local conditions. We are currently working with interested landowners and potential funders (for example energy companies) to determine ecosystem services and contract terms that would be amenable to buyers and sellers alike. We are using existing conservation plans that include ecological sites to determine which ecosystem services and locations in the basin would be optimal. This information will be used to conduct a pilot program on the properties of several landowners. We will present a status update on the program, including information acquired thus far from stakeholders and plans for program implementation over the next year.

Melanie Purcell. Sublette County Conservation District, PO Box 647, Pinedale, WY. 82941. Email: mpurcell@sublettecd.com.

Session IV C. Concurrent Topic: Evaluation of Habitat Treatments, Management Considerations, and Science Needs

The Wildlife Management Possibilities of Highway Underpasses.

Tony W. Mong, Wyoming Game and Fish Dept, Baggs, WY; Tim Woolley, Wyoming Game and Fish Dept, Cody, WY; Thomas Hart, Wyoming Dept of Transportation, Cheyenne, WY; Chadwick D. Rittenhouse, University of Wisconsin-Madison, Madison WI.

Wildlife underpasses are situated in areas where a highly dispersed population converges into a relatively small area along a migration corridor. In addition to reducing wildlife-vehicle collisions and maintaining migration corridor connectivity, use of underpasses by wildlife may provide valuable information for wildlife managers. We used a newly constructed underpass and associated trail cameras to collect data for mule deer in relation to timing of migration, classification of animals by sex and age class, and fawn survival over winter. From October 2009 to December 2010, we documented 12,130 deer using the underpass. We used a negative binomial analysis to test three hypotheses of factors affecting mule deer use of the underpass during fall migration of 2010 ($n = 5,354$): temperature, precipitation, and both temperature and precipitation. We found that deer use of the underpass was negatively associated with minimum daily air temperature and positively associated with snow depth. We compared underpass classification data with aerial classification data and found that aerial counts resulted in fewer fawns and adult bucks compared to the underpass data. Underpasses may increase the probability of detecting small-bodied (fawns) or solitary (bucks) individuals, and thus improve estimates of fawn and mature buck-to-doe ratios. By comparing the number of fawns per 100 adult deer between fall and spring migration we may be able to determine fawn survival over winter. Wildlife managers that have access to wildlife underpasses should consider their use for collection of important data for management and harvest regulations.

Tony Mong, Wyoming Game and Fish Dept. P.O. Box 516, Baggs, WY. 82321. Email: tony.mong@wyo.gov.

The Cumberland/Uinta Allotment: Success in Riparian Management with Livestock Grazing.

Ron Mitchell, and Jerry Pierce (Retired), BLM Kemmerer Field Office, Kemmerer, WY; Grazing Permittees of the Cumberland/Uinta Allotment, Uinta, County, WY.

The Cumberland/Uinta Allotment encompasses almost 400,000 acres of public, state, and private lands in southwest Wyoming and central Utah. The Cumberland/Uinta Allotment has been considered in the past, to be one of the most poorly managed areas in Wyoming. We will present information that, through the use of Coordinated Resource Management, good planning, good monitoring, and good people, positive change can happen. Through the development of a Mission Statement, and goals to support that Mission Statement, local people have address local problems and made significant progress in riparian habitats across a large landscape. We used multiple regression techniques to describe trend of desirable plant communities (DPC) over time on 10 different greenlines located in the Cumberland/Uinta Allotment. First degree, second degree, and third degree

polynomials were created for each greenline. The polynomial which provided the best coefficient of determination was selected to describe the trend on each of the 10 greenlines. We will show that under livestock grazing, with appropriate recovery periods tuned to the DPC, riparian vegetation composition and vigor can increase.

Ron Mitchell. BLM Kemmerer Field Office. 312 HWY 189 North. Kemmerer, WY. 83101. Email: r75mitch@blm.gov

Building a Better Product: Habitat Restoration Efforts and Emerging Research Needs.

Mark J. Hogan, USFWS, Lander, WY.

Historically, effective wildlife conservation consisted primarily of protecting against wanton killing. In the early 1930's, the combination of severe drought and declining wildlife numbers brought about the first major habitat restoration program the Federal Aid in Wildlife Restoration Act (Pittman-Robertson Act) of 1937. Joining efforts with State Wildlife Agencies, the Act funded wildlife research, species reintroduction, habitat acquisition, management and restoration, and hunter education and safety programs. It wasn't again until the mid-1980s with the implementation of the North American Waterfowl Conservation Act, 1985 Food Security Act (Farm Bill) Conservation Provisions and establishment of the US Fish and Wildlife Service Partners for Fish and Wildlife Program that unprecedented opportunities were created for habitat restoration on private lands. The U.S. Fish and Wildlife Service's Partners for Fish and Wildlife Program (PFW) has been actively providing financial and technical assistance to restore and enhance fish and wildlife habitat in Wyoming since 1988. A program overview, site, and landscape decision making process review, and research/monitoring opportunities will be the emphasis of discussion.

Mark Hogan, USFWS WY PFW. 170 North 1st Street. Lander WY. 82520. Email: mark_j_hogan@fws.gov.

Synthesis of Lower Treeline Limber Pine (*Pinus flexilis*) Woodland Knowledge, Research Needs, and Management Considerations.

Robert E. Means, BLM Wyoming State Office, Cheyenne, WY.

Lower treeline limber pine woodlands are ecologically distinct ecotonal systems which have received little attention in scientific research. Their position on the lower treeline and foothills in semi-arid climate systems is predicted to be particularly vulnerable to climate change. These limber pine woodlands are often thought to be "invading" more desirable vegetation types, so eradication has been an accepted practice to limit "encroachment". The lack of economic value fosters the perception that these lower treeline woodlands are "weeds" which need to be controlled and maintained only on steep rocky slopes that will not support other vegetative types. Their expansion into grass and shrublands is thought to be solely from management actions such as wildland fire suppression and livestock grazing. This view does not account for the dynamic relationships between climate, vegetation, and disturbance that the ecotones between different biomes respond to. Current base line vegetation models are based on vegetative

communities that developed under different climatic conditions than are forecasted for the future. Current climate models for these areas predict an increase in temperature of between 1° to 7° F. Changes in precipitation are also predicted, with a summer precipitation decrease from 10 to 50 percent and winter precipitation increase from 10 to 25 percent. The concept of Stationarity, that natural systems fluctuate within an unchanging envelope of variability, has been the foundation for the practice of natural resource management. Because of the rapidly changing climate conditions, this envelope no longer exists. Not enough is known about the lower treeline limber pine and the biotic communities dependent upon them to assume traditional management activities. A series of carefully delineated basic and applied research questions needs to be formulated and answered to provide a fuller understanding of the ecological role(s) of lower treeline woodlands and to change the current management paradigms.

Robert E. Means, Bureau of Land Management, Wyoming State Office, 5353 Yellowstone Road, Cheyenne, WY, 82009, Email: rmeans@blm.gov.

Session IV D. Reclamation and Restoration of Disturbed Lands and Important Aquatic and Terrestrial Habitats

Muddy Creek Culvert Removal and Channel Restoration 2010.

Nick Walrath, Green River Project, Trout Unlimited, Lander, WY.

In the fall of 2010, Trout Unlimited teamed up with a group of project partners to remove an old culvert that was no longer needed on Muddy Creek (tributary to the Little Snake River, south central Wyoming). This culvert was perched, created a barrier that was impassable for native fishes and the stream channel was extremely incised. The BLM had already installed a bridge upstream from the culvert so it was no longer needed. However, simply removing the culvert would have allowed a head-cut to continue upstream causing further channel incision and mobilizing large quantities of sediment. The old channel was filled in and the new channel was built back on top of its original flood plain. The completed project has approximately 2,500 feet of reconstructed channel. The project has increased the riparian area, provided fish passage and enhanced the fish and wildlife habitat. In the spring of 2011, Muddy Creek experienced extremely high flows for an extended amount of time. The project was completed in November of 2010 and no growing season was given to the riparian areas going into winter. The natural channel design held up over the spring and only two small areas had to be addressed in the summer of 2011 due to flooding.

Nick Walrath, Green River Project, Trout Unlimited, Laramie, WY, 82070. Email: hjones10@uwyo.edu.

Options for Native Plant Material Development in the Southern Rocky Mountains.

Steve Parr, Upper Colorado Environmental Plant Center, Meeker, CO.

The development of native plant materials has historically followed a systematic process where testing of multiple collections or accessions of a given species at multiple locations has been the driving force for selection and release. However, resource needs of various land management agencies coupled with concerns of long term genetic alteration of

indigenous populations has led to the production of many source specific products that are largely untested. Observed phenotypic attributes of a given accession or releases are sometimes deemed less important than origin of source. The complexities involved in native plant material development require the right match of product growth and expansion to fit customer needs. The success of the development process is tied directly to initial planning between the developing party and the end user. The benefits as well as shortcomings of different native plant material development processes that are currently being conducted at Upper Colorado Environmental Plant Center are presented.

Steve Parr, Upper Colorado Environmental Plant Center, Meeker. 5538 County Road 4. Meeker, CO. 81641. Email: steve.parr@co.nacdnet.net

Five Year Results of “Seed Mixture” Re-vegetation Trials in the Pinedale Anticline Project Area.

Karen J. Clause, USDA NRCS, Pinedale, WY; Susan R. Winslow, USDA NRCS Plant Materials Center, Bridger, MT; Jim Jacobs, WY USDA NRCS, Bozeman, MT.

Critical wildlife habitat supporting mule deer, antelope, and sage grouse in high elevation rangeland and sagebrush ecosystems of southwest Wyoming is threatened by energy development and residential sprawl, resulting in a fragmented landscape and a declining forage base. Restoring disturbances with diverse plant communities is needed. Our objectives were to assess establishment and persistence of native plants, and to test seed mixtures and seeding techniques. In October 2005, two seed mixtures were broadcast- and drill-seeded, and one seed mixture was hydro-seeded on disturbed areas adjacent to the monoculture plots. Density by species was counted in mixture plots. Seed mixture results were variable, but 5-year average data supports the recommendation to broadcast smaller seeded species and drill seed larger seeded species. In addition, higher seeding rates do not necessarily translate to higher establishment rates; and aggressive rhizomatous species may out-compete other components of the mix. Final project results provide recommendations for native plant restoration and species adaptation to the area. Relatively low establishment of forbs and shrubs indicate more work is needed to develop these plant materials and technologies.

Karen J. Clause, USDA NRCS, Pinedale, WY; Susan R. Winslow, USDA NRCS Plant Materials Center, Bridger, MT; Jim Jacobs, USDA NRCS, Bozeman, MT. Email: karen.clause@wy.usda.gov.

Five Year Results of “Replicated Plot” Re-vegetation Trials in the Pinedale Anticline Project Area.

Karen J. Clause, USDA NRCS, Pinedale, WY; Susan R. Winslow, USDA NRCS Plant Materials Center, Bridger, MT; Jim Jacobs, USDA NRCS, Bozeman, MT.

Critical wildlife habitat and sagebrush ecosystems of southwest Wyoming are threatened by energy development and residential sprawl, resulting in a fragmented landscape and a declining forage base. Restoring disturbances with diverse plant communities is needed. Our objectives were to assess establishment and persistence of native plants, and to test seed mixtures and seeding techniques. In October 2005, 72 entries of 50 native species were drill-seeded on a shut-in well-pad site, in single species plots in a randomized

complete block design with four replications. Also, two seed mixtures were broadcast-and drill-seeded, and one seed mixture was hydro-seeded on disturbed areas adjacent to the monoculture plots. In replicated plots, density of seeded species was recorded in each of the 5 years post-seeding, and biomass was clipped from grass plots for 3 years in 2008-10. Density by species was counted in mixture plots. In replicated plots, ANOVA showed plant counts depended on seeded species. Top performing grasses with greater than 2 plants/square foot in 2010 were Sodar streambank wheatgrass, Critana thickspike wheatgrass, L-46 basin wildrye (not released), P-24 bluebunch wheatgrass (not released), Rodan western wheatgrass, and Washoe basin wildrye. No forb or shrub densities exceeded 1 plant/square foot, a common measure of re-vegetation success for the area. Seed mixture results were variable, but 5-year average data supports the recommendation to broadcast smaller seeded species and drill seed larger seeded species. In addition, higher seeding rates do not necessary translate to higher establishment rates; and aggressive rhizomatous species may out-compete other components of the mix. Final project results provide recommendations for native plant restoration and species adaptation to the area. Relatively low establishment of forbs and shrubs indicate more work is needed to develop these plant materials and technologies.

Karen J. Clause, USDA NRCS, Pinedale, WY; Susan R. Winslow, USDA NRCS Plant Materials Center, Bridger, MT; Jim Jacobs, USDA NRCS, Bozeman, MT. Email: karen.clause@wy.usda.gov.

Shrub Translocation/ Relocation for Habitat Enhancement for the Greater Sage-Grouse in Southwestern Wyoming.

Deej Brown, BLM Kemmerer Field Office, Kemmerer, WY.

In 2006 a pilot project was developed to relocate Wyoming Big sage (*Artemisia tridentate* ssp. *Wyomingensis*) to areas disturbed by the oil and gas industry, their contractor, and the BLM. This project proved to have more benefits than just the salvage of mature sage brush, in that it was able to create micro habitats for other vital native plants and organisms that the Greater sage grouse (*Centrocercus urophasianus*) rely upon for survival. Methods used for the projects identified reclamation locations free of undesirable plants, within Greater sage grouse habitat, and a dense sage brush area that was associated with grasses and forbs no more than 75 meters from the relocation site. The project location had disturbance of +/- 7.5 acres, with a total maximum project area of +/- 16.2 acres. 1000 shrubs were relocated on the first project site while only removing one shrub for every 66 square meters. This location had a 90% survivorship in the first year, there were four other locations planted at the same density as the offsite (865 total plants) resulting in 45% survival with those that did not survive having 99% survival of the grasses and forbs that were translocated with the shrubs. Shrubs that did not survive caught snow and held much needed moisture supporting grasses and forbs that were moved with the shrub leading to a more diverse and healthy stand of native plants, that supply needed rescues for brood rearing for the Greater sage grouse as well as a jump on the habitat to be restored to its natural ecological site characteristics. This application can aid in the enhancement of habitat for the Greater sage grouse within critical core areas not only in oil and gas development but as a practical landscape application.

Brown, Deej. BLM Kemmerer Field Office. 312 HWY 189 North. Kemmerer, WY. 83101. Email: debrown@blm.gov.

Homogenization in Vegetation and Soil Following Disturbance and Reclamation in Sagebrush Steppe.

Caley Gasch, Department of Ecosystem Science & Management; Peter Stahl, Department of Ecosystem Science & Management; Snehalata Huzurbazar, Statistics, University of Wyoming, Laramie, WY.

Drastic land disturbance associated with fossil fuel extraction is widespread throughout intermountain sagebrush steppe lands. Reclamation efforts across sagebrush steppe in Wyoming have been successful in reestablishing herbaceous biomass (often exceeding that of undisturbed sites), but restoration of the dominant sagebrush component (*Artemisia tridentata*) has proven difficult. The sagebrush steppe vegetation community possesses patchiness and heterogeneity. These shrub-associated spatial patterns are apparent belowground in abiotic and biotic soil properties and influence distribution of water and nutrient cycling. We hypothesize that drastic disturbance (vegetation removal and topsoil handling) alters the degree of variability and spatial structure of both aboveground and belowground communities. Specifically, we predict that disturbed and reclaimed areas experience homogenization in above- and belowground properties. We established plots on a chronosequence of reclaimed pipelines and adjacent undisturbed reference areas in south central Wyoming. Vegetation and soils (0-5 cm) were sampled and analyzed for physical, chemical, and biological properties. Results suggested that recently reclaimed areas had more vegetative biomass, and more homogeneous and continuous vegetative cover. Conversely, undisturbed plots displayed a more patchy distribution of a more diverse plant community. Reclaimed plots of all ages also demonstrated less variability in soil characteristics, and these belowground patterns appeared to be associated with the vegetation. These findings emphasize the potential importance of reestablishing the sagebrush component on disturbed lands for successfully restoring ecosystem structure and function.

Caley Gasch, Department of Ecosystem Science & Management. University of Wyoming. 3354 1000 E. University Ave. Laramie, WY. 82071-3354 Laramie, WY. Email: cgasch@uwyo.edu.

Investigating and Improving Sagebrush Reclamation in Bentonite Mining Areas of the Bighorn Basin.

Zachary J. Liesenfeld, Department of Ecosystem Science & Management; Lyle King, Department of Ecosystem Science & Management; Peter Stahl, Department of Ecosystem Science & Management, University of Wyoming, Laramie, WY.

The Bighorn Basin located in north central Wyoming has some of the largest deposits of quality bentonite throughout the world. Historically, reclamation efforts to establish plant communities similar to premine sagebrush (*Artemisia tridentata*) grassland plant communities have been limited due to the absence of shrub regulatory standards and poor response of sagebrush to reclamation efforts on bentonite mine lands. The lack of suitable shrub cover is believed to have a negative effect on sagebrush obligate species, such as the greater sage-grouse (*Centrocercus urophasianus*). The objective of this study is to determine if sagebrush communities are reestablishing on reclaimed bentonite mined lands under conventional reclamation techniques. Our data indicate that sagebrush establishment on reclaimed bentonite lands in the Big Horn Basin has not been successful using conventional methods. Five study sites were reclaimed in the past 15 years, while

six were reclaimed more than 15 years ago. The younger sites have a mean sagebrush density of 900 stems hectare⁻¹ while the older sites have a mean of 5140 stems hectare⁻¹. Native reference sites have a mean sagebrush density of 10,763 stems hectare⁻¹. Even the densities of the older reclaimed sites are only about half of observed sagebrush densities on native reference sites. These results are interpreted as indicating that conventional methods of sagebrush reestablishment used in bentonite mineland reclamation are ineffective in the short term, 15 years or less. That is, initial seeding efforts during site reclamation result in very little sagebrush establishment. However, over the long term, natural seed dispersal of native sagebrush from undisturbed areas surrounding reclaimed mine sites appears to have resulted in reestablishment of greater densities of sagebrush plants. It is also believed that other newly developed reclamation technologies may be effective in reestablishing formidable sagebrush communities on reclaimed bentonite mined lands.

Zachary J. Liesenfeld, Department of Ecosystem Science & Management. University of Wyoming. 3354 1000 E. University Ave. Laramie, WY. 82071-3354 Laramie, WY. Email:

Restoration of Sagebrush Landscapes Jonah Field

Joshua Sorenson and Ralph Swift (Retired), Encana Oil & Gas (USA) Inc., Pinedale, WY.

The Jonah Field is located approximately 30 miles south of Pinedale and encompasses about 30,000 acres. The annual precipitation in the area ranges from 7-9 inches and the vegetation consists of a mixed sagebrush and wheatgrass landscape. The northeastern part of the field has more dense sage and grass and has within it an active sage grouse lek. The southern part of the field is typified by clayey landscapes shallow to shale. A large scale reclamation program was implemented as part of the EIS decision in 2006 to allow drilling on 5 to 10 acre spacing. The program included soil testing prior to location construction, separating top soil from subsoil, deep ripping of locations after they were re-contoured, prior to top soiling, irrigation, fertilization and seeding with native seed mixes. This past 5 years the average amount of Reclamation has been around 500 acres per year. Success is being seen in establishment of sagebrush through seeding and other native grasses that had been lost over time with the spring grazing. Native Forbs are still a problem based on seed sources. Current records show that approximately 75% of all disturbances are in the reclamation process and of those 60% are showing progress toward reclamation criteria for Roll Over credit as established by the Jonah Interagency Office.

Joshua Sorenson P.O. Box 2060. Pinedale, WY. 82941. Email: Joshua.sorenson@encana.com.

Poster Presentation

Exotic Annual Brome Invasion and an Integrated Aboveground-belowground Assessment of Ecosystem Properties.

Caley Gasch, Dept. of Ecosystem Science & Management; Stephen Enloe, Dept. of Plant Sciences; Stephen Williams, Dept. of Ecosystem Science & Management; Peter Stahl, Dept. of Ecosystem Science & Management, University of Wyoming, Laramie, WY.

Exotic annual brome invasion has been well studied in the intermountain west, particularly for *Bromus tectorum* L. invasion in sagebrush (*Artemisia tridentata*) grasslands. While studies have quantified effects of invasion on vegetation, soil properties, or biotic interactions, few attempts have been made to simultaneously characterize many aboveground and belowground ecosystem properties of areas invaded by exotic annual bromes. We examined both aboveground and belowground properties in native sagebrush grassland and adjacent areas dominated by exotic annual bromes (*B. tectorum* L. and *Bromus japonicus* Thunb.) to better understand the fundamental ecological differences between native and invaded areas, and to better inform restoration needs. Field sites were located in north central Wyoming, and plots were established in areas that had been historically subject to wildfire and either recolonized by native sagebrush grassland vegetation, or invaded by exotic annual bromes. We employed measures of vegetation community structure as well as soil physical, chemical, and biological properties. Plots with greater than 20% exotic annual brome cover had significantly less cover of all native vegetation functional groups resulting in lower richness and evenness than native plots. Invaded plots also have more homogeneous plant community according to a multi-scale assessment of community structure. Soils beneath invaded plant communities had higher infiltration rates, higher levels of total nitrogen, and a lower C:N ratio than the native soils. Invaded soils also had 90-96% lower abundance of all soil microbial groups measured. Discriminant analysis indicated a strong separation of both aboveground and belowground characteristics associated with each vegetation type. Regardless of which factors cause these differences on the landscape, restoration efforts should focus on manipulation of ecosystem properties in concert, rather than targeting the presence or ecology of the invasive species alone.

Caley Gasch, Department of Ecosystem Science & Management, University of Wyoming, 3354 1000 E. University Ave. Laramie, WY. 82071-3354 Laramie, WY. Email: cgasch@uwyo.edu.

Assessing Socioeconomic Planning Needs (ASPN) Decision-Support Tool.

Jessica M. Montag, Leslie Richardson, Lynne Koontz, Natalie Sexton, USGS Fort Collins Science Center, Fort Collins, CO.

Lands and resources managed by federal agencies provide many goods and services that contribute to the social and economic well-being of local communities and society as a whole. These include such benefits as recreational opportunities, commercial uses, ecosystem services, and subsistence. Management actions on these lands can affect various private and public stakeholders who often have diverse values and preferences about the use and management of public resources. Therefore, these social and economic impacts of planning and management need to be adequately and systematically addressed, particularly in controversial situations where diverse stakeholders are highly engaged and may contest management decisions. USGS scientists have worked with the BLM, NPS, and USFS to develop a web-based decision tool for Assessing Socioeconomic Planning Needs (ASPN) which enables natural resource managers and planners to develop custom socioeconomic assessment plans tailored to their individual land units and specific planning needs. ASPN allows planners and managers to establish the broad social and economic themes they may want to address, identify sub-issues to assess under those broad themes; and determine the intensity of the issues. ASPN then suggests analysis methods for addressing the identified issues using various inputs

including time and budget needs. This tool will improve the planning process by: 1) systematically covering the breadth of issues facing land and resource management agencies; 2) identifying and prioritizing the planning issues that will require a social and/or economic analysis in the management plan; 3) providing a range of recommended social and economic methods which could be used to address the identified planning issues 4) realistically accounting for budget and time constraints; 5) including consideration of appropriate regulations regarding environmental policy; and 6) providing justification and documentation of the chosen analysis and tools.

Jessica M. Montag, USGS Fort Collins Science Center, 2150 Centre Ave., Bldg. C, Fort Collins, CO 80526-8118, Email: montagj@usgs.gov.

Sublette County Conservation District's Programs and Activities.

Eric Peterson, General Manager, Sublette County Conservation District, Pinedale, WY.

Sublette County Conservation District is a major player in the Sublette County Conservation Landscape. Featuring eight major programs, this poster will help viewers understand our breadth and capability. The programs are: 1) Surface Water Quality Monitoring – The surface water program’s goal is to maintain vigilance of our water. A network of 54 water quality stations monitors every major stream in the county. The majority of these 54 stations are monitored several times a year, most of them five times; 2) Ground Water Quality Monitoring - The program monitors about 300 groundwater sources. The bulk of sources are domestic water wells, but about 60 industrial and stock water wells on and around the Anticline area are monitored for water levels, physical and chemical parameters, including analysis for hydrocarbons; 3) Range Management Program - The Range program documents use, condition, and trend of the rangelands, particularly in the Boulder, Ryegrass, and North LaBarge Landscapes, as well as a number of individual allotments; 4) Wildlife and Habitat Program - Focusing on Conservation Planning and quantifying environmental services provided by lands within the county, the district Conservation Plans are a comprehensive inventory and planning process done in cooperation with a landowner; 5) Sage-grouse Initiative - To assure the long-term conservation of the bird, the district partners with other entities to employ a scientist whose focus is to work with landowner strategies and infrastructure to improve long-term sustainability of grouse; 6) Conservation Tree Program - Providing trees to landowners at nominal costs, literally thousands of trees populate our private landscapes as result of landowner involvement in the program; 7) Youth Education Program - The District employs a youth education specialist on a part-time basis, carrying the message of conservation to our youth in afterschool and school enrichment programs; and 8) Partnerships - In addition to these Sublette Conservation District initiatives, the district partners with many agencies and individuals to accomplish conservation in the county.

Eric Peterson, General Manager, Sublette County Conservation District, Box 647, Pinedale, WY, 82941. Email: epeterson@sublettecd.com.

Identification and implementation of Native Fish Conservation Areas in the Upper Colorado River Basin

Daniel C. Dauwalter, Trout Unlimited, Boise, Idaho John S. Sanderson, The Nature Conservancy, Ft. Collins, CO; Jack E. Williams, Trout Unlimited, Medford, OR; James R. Sedell, National Fish and Wildlife Foundation, Portland, OR.

Freshwater fishes continue to decline at a rapid rate despite substantial conservation efforts. Native Fish Conservation Areas (NFCA) are a management approach emphasizing persistent native fish communities and healthy watersheds while simultaneously allowing for compatible human uses. We identified potential NFCAs in the Upper Colorado River Basin – focusing on Colorado River cutthroat trout (*Oncorhynchus clarkii pleuriticus*), flannelmouth sucker (*Catostomus latipinnis*), bluehead sucker (*Catostomus discobolus*), and roundtail chub (*Gila robusta*) - through a process that combined known and modeled species distributions, spatial prioritization analysis, and stakeholder discussions. The network of potential NFCAs is intended to serve as a funding framework for a National Fish and Wildlife Foundation Keystone Initiative focused on Colorado River Basin native fishes. We discuss current opportunities for and impediments to implementing NFCAs over the long-term, including current collaborative restoration efforts in Muddy Creek, south-central Wyoming.

Daniel Dauwalter, Trout Unlimited, 910 Main Street Suite 342. Boise, ID. 83702.
Email: ddauwalter@tu.org